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Long Span Reinforced-Concrete Girder Bridges.

By F. W. SCHEIDENHELM.*

The West Penn Rys Co., covering the entire coke producing region of Southwestern Pennsylvania, with a total of 154 miles of track, is one of the largest electric interurban railways in the country. One of the latest branches of the road is the Brownsville extension, a 10-mile single-track line connecting with the Uniontown-Masontown line at Footedale and running into Brownsville on the Monongahela River. On this branch there are five bridges, three of standard steel construction, with concrete abutments, and two, bridges "B" and "C," each a series of concrete girders on high, slender concrete piers. In these latter two, both over Dunlap's Creek, the girders are of such length and the design enough out of the ordinary as to warrant description.

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FIG. 1. BRIDGE "B" ON THE BROWNSVILLE EXTENSION OF THE WEST PENN RAILWAYS CO., NEAR BROWNSVILLE, PA.

Large span is a 67-ft. reinforced-concrete girder.

FIG. 2. VIEW OF BRIDGE "C" NEAR THE END OF ITS CONSTRUCTION.
(Large Span is a 75-ft. Reinforced-Concrete Girder.)

Grading for the Brownsville extension was begun early in the spring of 1907. At this time also the question of type and design of the various bridges required was taken up. Work on the reinforced-concrete bridges, however, was not begun until in the early part of July. The first of the bridges was ready for service Oct. 24, 1907, and the second on Jan. 27, 1908. The bridges, however, were not put into regular service until Jan. 2, 1908.

Bridge "B" (Fig. 1) has a total length of 192 ft., with four spans of 40, 45, 67 and 40 ft., respectively. The gross girder depth of the main or 67-ft. span is 72 ins., but in the three remaining spans, partly for the sake of appearances and partly as a matter of economy, it was made the uniform depth of 48 ins. This bridge, owing to the topography of the approaches and the span arrangement, presents a quite symmetrical appearance. Bridge "C" (Fig. 2) has a total length of 130 ft. and consists of three spans, 25, 30 and 75 ft. long, respectively. The gross depth of the 25 and 30-ft. spans is 42 ins., while that of the 75-ft. span girder is 84 ins. The conditions to be met called for an unsymmetrical design; hence this bridge is not as pleasing to the eye as is bridge "B." The building of bridge "C," however, involved the construction of the longest span to this date of any reinforced-concrete girder bridge for railway loading. Previously the record has been held by a viaduct on the Richmond & Chesapeake Bay Ry.,* the Clay St. span of which is 67 ft. 5 ins. in length.

That the 75-ft. span of bridge "C" does not necessarily mark the economical limit of span length in reinforced-concrete girder construction for heavy loading is indicated by the fact that the West Penn Rys. Co., at the instance of the writer, is considering the construction of a 100-ft. span for a bridge on a proposed extension. It is undoubtedly true, however, that such a length of span is economical only under special conditions. In other words, girder construction and arch construction both present strong claims upon the designer when the span length is in the neighborhood of 60 or 75 ft. Above that length, and often below, ordinary conditions would probably call for arch design.

Problems.

The decision to be made initially in the case of the Brownsville Line bridges was that between standard steel construction as against reinforced-concrete construction. At the time the question of reinforced-concrete construction was taken up, steel structures for both sites "B" and "C" had already been designed and bids had been received. In fact, a contract had been let for concrete abutments and piers for the standard steel superstructures which had been designed. This contract was temporarily held up while preliminary designs and estimates were prepared for reinforced-concrete structures. Finally the contract for the two reinforced-concrete bridges, complete, was awarded to the same company which originally had the contract for the concrete abutments and pedestals only.

The general designs of both bridges were changed when the substitution of reinforced concrete for standard steel was made. For bridge "B" there had originally been planned a single 100-ft. span, with high wing wall abutments. In the reinforced-concrete design for the bridge, however, the length was nearly doubled and the costly abutments avoided, as also a large earth fill. The north abutment was practically done away with, for instead of carrying the fill out to the edge of the creek the ends of the north 40-ft. span girder were rested upon a reinforced-concrete pad at the edge and near the top of the bluff, shown at the right in Fig. 1. The south abutment, too, was moved back from the creek and, instead of being designed with heavy wing walls, was buried in the earth fill.

In the case of bridge "C" the steel design called for two spans, 40 and 80 ft. in length, respectively. The reinforced-concrete design involves three spans and an increase in the length of the bridge of ten feet. The situation demanded a long span. By placing the south pier of this span just at the edge of the creek it was found possible to fit in a 75-ft. span. The north abutment rests on rock on the bluff shown at the left in Fig. 2. This also resulted in a considerable saving over the original scheme, which at the north end called for a wing-wall abutment on lower ground directly at the edge of the creek.

As stated above, the 75-ft. span was a step beyond previous attempts. Therefore, the feasibility of constructing a span of that length was carefully considered and assumed only after a careful analysis of the situation and of the possibilities of a reinforced-concrete design had been made. Arch construction was considered, but was abandoned for the following reasons.

Owing to the considerable height of the bridge above the creek, it did not seem economical to build an abutment on the one side which would be capable of taking arch thrust at such a height. In addition, the more expensive formwork required for arch construction as against simple girder construction bore considerable weight. An important factor entering also was the advisability, practically a necessity, that the contract should be given to the company originally having the contract for the plain concrete abutments, and that the experience of this company had not extended into reinforced-concrete arch construction. It was thought that from inexperienced contractors better results could be obtained through the simpler girder construction. The decision in favor of the latter was amply justified by the experience later in actual construction.

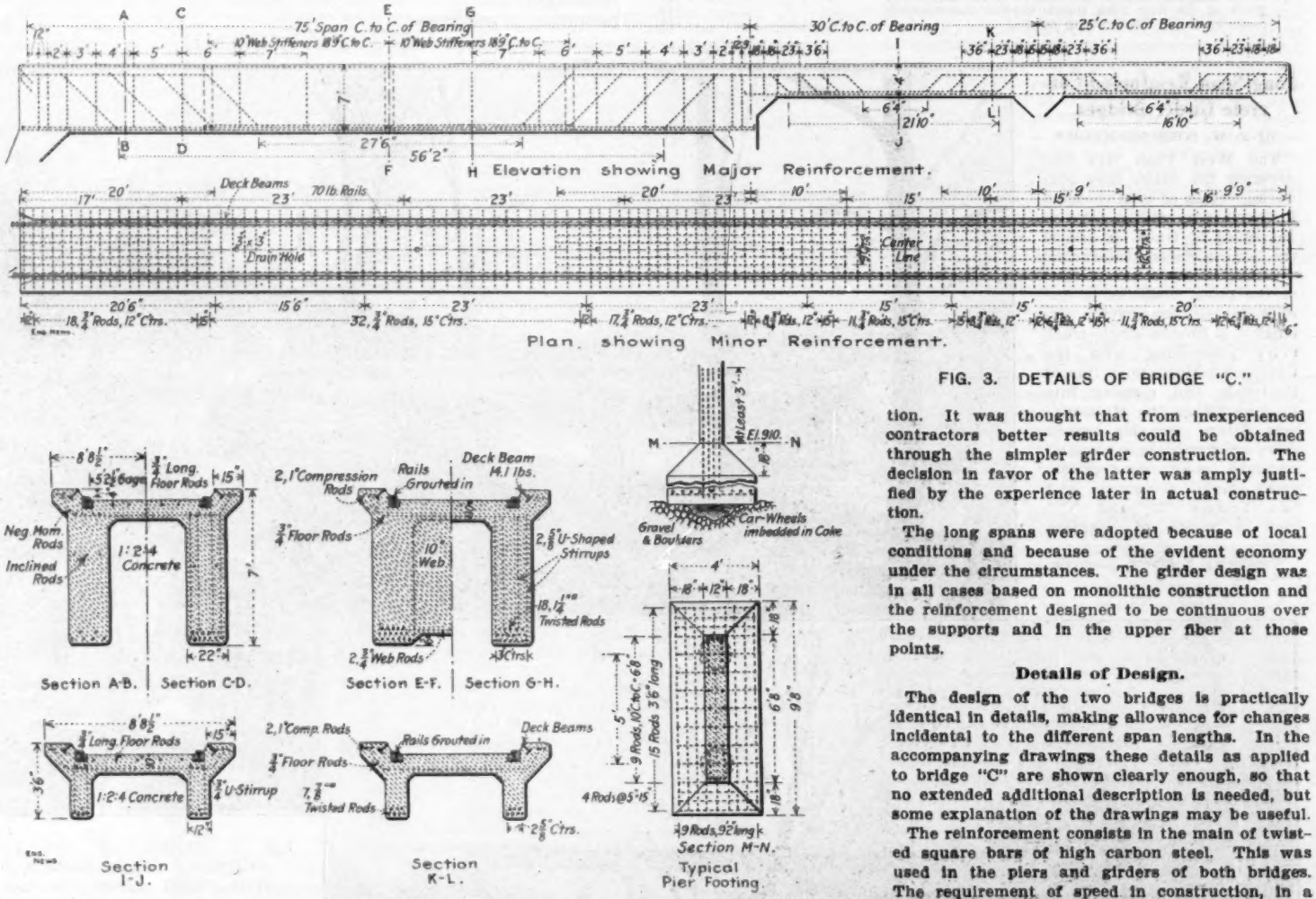


FIG. 3. DETAILS OF BRIDGE "C."

The long spans were adopted because of local conditions and because of the evident economy under the circumstances. The girder design was in all cases based on monolithic construction and the reinforcement designed to be continuous over the supports and in the upper fiber at those points.

Details of Design.

The design of the two bridges is practically identical in details, making allowance for changes incidental to the different span lengths. In the accompanying drawings these details as applied to bridge "C" are shown clearly enough, so that no extended additional description is needed, but some explanation of the drawings may be useful.

The reinforcement consists in the main of twisted square bars of high carbon steel. This was used in the piers and girders of both bridges. The requirement of speed in construction, in a period when it was difficult to obtain material, made it necessary to use a makeshift in the case of the footing and abutment reinforcement. In these cases the reinforcement consisted of discarded mine haulage cable. This material was easily obtained from the mines in the region and was in surprisingly good condition.

It was determined to do all of the fabrication in the field. Therefore the twisted square steel rods were bought straight, though cut to lengths according to detail drawings. The field fabrication, which consisted merely of bending, was accomplished by a blacksmith with several helpers. A common blacksmith's forge and anvil were set up, first at bridge "C" and later at bridge "B."

The question of joints in the reinforcement of the long span received serious and extended consideration. On account of the extreme length required, amounting to about 80 ft. in some cases, it was deemed impracticable to use rods of that total length. A joint made by lapping the rods inside of a pipe, hooking the rods over the ends

*Eng. News, Dec. 12, 1907, p. 625.

of the pipe and then filling the pipe with grout, was suggested. This joint was tested and on the basis of this test condemned. The ordinary lap joint was finally adopted, while a special clamp was used as additional precaution. The special splice clamp was made up of stock ⅝-in. eyebolts 6 ins. long which were bent to fit the reinforcing bars, with the eyes hammered to an oblong shape so as to fit the body of the bolt. The details of the clamp are shown in Fig. 6.

This joint proved to be comparatively easy to assemble in the field; also it was well suited to the limited space which was available for the individual joints on account of the large number of rods and consequent close spacing of reinforcement. The end of each lapped rod was hooked at right angles for 2 ins. All of the lap joints were clamped as shown in the following:

Size of Bars. Ins.	Length of Lap. ft.	ins.	No. of Clamps.
1¼—1¼	4	0	4
1 —1	3	6	3
⅞— ⅞	3	0	3
1¼— ⅞	4	0	3
1⅛—1	4	0	4

In all cases a clamp was placed against the hook at each end of the joint, while the intermediate clamps were spaced uniformly.

Stirrups were used which were separate from the main reinforcement but which were placed in close contact with the main bars and wired to the same. In the large girders the stirrups, which were also of twisted square steel bars, were placed in pairs, a smaller U-shaped stirrup being placed inside of a larger "U," both being of ⅝-in. steel. In the smaller girders the stirrups were placed singly and were of ¾-in. steel.

The girders were connected and stiffened at all piers and abutments by continuing the web piers and the face walls of the abutments solidly between the girders up to the bridge deck. The deck is uniformly 10 ins. thick and is provided at intervals with drain holes. These drain holes in the case of bridge "C" are 3 × 3 ins., but in the case of bridge "B" it was deemed advisable to enlarge them to 4 × 4 ins.

Web stiffeners between the deck and girders were also used intermittently in the long spans. In the 75-ft. span of bridge "C" three were used equally spaced. In the case of bridge "B" two stiffeners, equally spaced, were used for the 67-ft. span and one each for the 40 and 45-ft. spans.

A decided innovation was the method of track construction. Instead of the usual trough deck with ballast fill and ordinary track construction, the rails were embedded directly in the floor slab. In doing this forms were first placed in the floor-slab, when that was being cast, leaving longitudinal grooves at the track locations. In these grooves the rails were set and cement grout poured around them, filling up the groove. The rails were continuous end to end.

Another novel feature is the extension of the girders above the deck to form a guard; or, vice versa, concrete guards were designed which at the same time act as portions of the girder section. The details of this construction are evident from Fig. 3. At the inner edge of the guard section a deck or bulb beam was embedded, the bulb of the beam being exposed and forming the actual edge with which a derailed wheel would come in contact.

No provision was made in the small intermediate piers for the thrust lengthwise of the bridge due to the braking or skidding of cars. It was intended that the girders should transfer such thrust to the abutments which were designed to amply take care of such stresses.

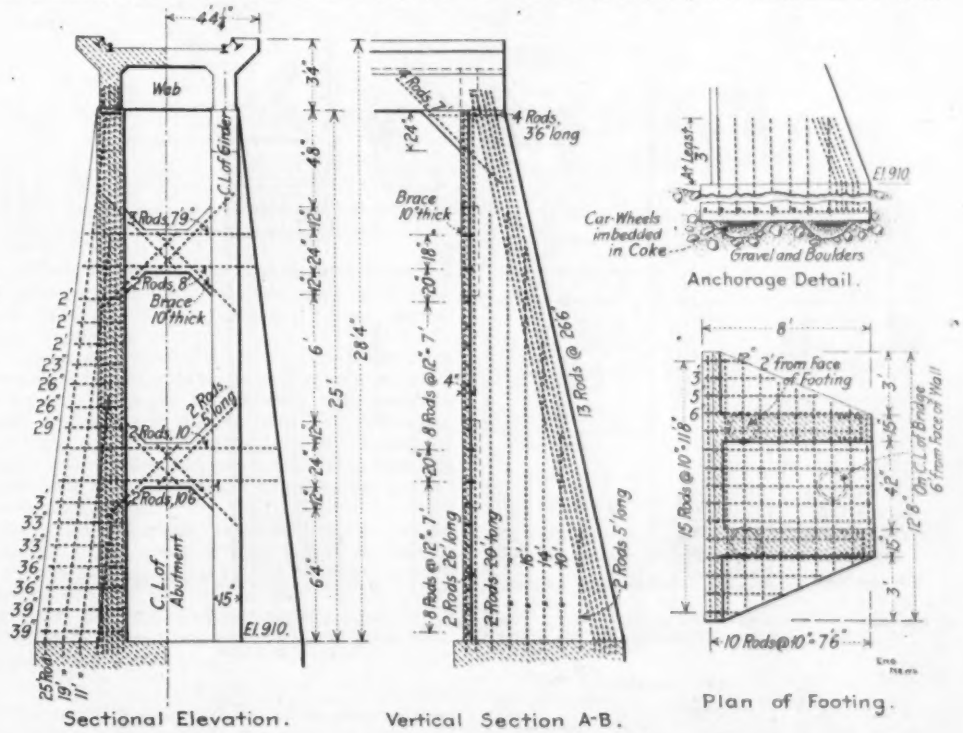
The monolithic character of girder construction was carried out by building the girders directly into the abutments and tying the girders into the back or tension fiber of the abutment buttresses. In the design, however, the safer assumption was made that the end girders of each bridge were continuous at the inner end and non-continuous at the outer end (i. e., the end of the bridge).

PIERS AND ABUTMENTS.—In all cases the pier reinforcement was extended up into the girders. The pier reinforcement consisted of ¾-in. twisted square steel bars, details of which are shown in Fig. 5. A spiral winding was used in addition, the piers being hooped with two No. 3 iron wires wound 6 ins. apart, thus giving a pitch of 12 ins. and a rise of 3 ins. per side. The greater part of the vertical pier reinforcement was placed near the outer edges of the long dimension in order to provide against the wind stress on the girders and train load.

In the design of piers decision was made in favor of solid web piers as against posts. This was due to the evident simplicity of construction and the economy in form-work.

The south abutment of each bridge presented rather difficult problems. Each of these abutments was designed to be buried in the fill which formed the bridge approach. Such a situation, of course, causes an unbalanced pressure on the abutment and, as the railway company's engineers had learned by previous experience, the action of such a buried abutment is by no means similar to that of posts or piers in ordinary fill.

The unbalanced pressure was aggravated by the character of the material used in the fill.



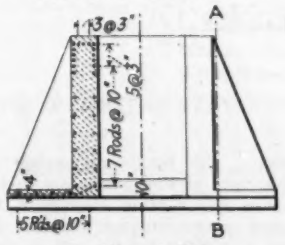


FIG. 4. DETAILS OF ONE ABUTMENT, BRIDGE "C."

This consisted of clay, stone and shale, the whole forming a treacherous mass having a tendency toward sliding. The problem presented was solved by designing skeleton abutments, the details of one being shown in Fig. 4. It will be noted that it consists of buttresses built up on a spread footing acting as a heel, the earth load on which prevents overturning. These buttresses were designed with heavy reinforcement extending from the rear of the heel along the inclined edge of the buttress and up into the ends of main girders.

Instead of being tied together by a solid face wall, the buttresses are joined by stiffeners, the net section of which is only 10 × 24 ins. The resulting openings allow the earth to spill through the abutment and in a large measure relieve the unbalanced pressure.

That this type of construction is successful as compared with the action of solid concrete abutments under the same conditions has been proved by a direct comparison in the case of abutments of other bridges of the Brownsville extension.

The creek piers of bridge "B" it was found practicable to carry down to solid rock not far below creek bottom. The small pier of bridge "C," however, was rested on gravel and boulders, since a test pit and drilling located no rock 14 ft. below the surface. Here, too, a spread footing with outside dimensions of 4 ft. × 9 ft. 8 ins. has met the situation very satisfactorily. The bottom of the spread footing is but 6 ft. below the surface.

Electrolysis Tests.

The possibility of electrolysis was recognized and provided against. The current used on the West Penn Rys. Co. system is 550 volts d. c. It was therefore determined to make a careful investigation into the effect of direct current on reinforced concrete. The situation was the more severe in the case under consideration because of the embedment of the rails directly in the concrete. As a part of this investigation the writer, assisted by Mr. L. O. Veser, made a series of tests at the main power station of the West Penn Rys. Co., where connection to 550-700 volt d. c. feeder lines was convenient.

The main results shown by the electrolysis tests were: (a) a definite and continued corrosion of the steel when acting as an anode, and the disintegration of the surrounding concrete; (b) no action upon the surrounding concrete when the current passed through an all-steel path; (c) no action upon the concrete surrounding the end of a steel bar when the bar was insulated by 6 ins. of *dry* concrete, that is concrete protected from water, or with a water-proofed surface, as distinguished from concrete exposed to rain or placed in damp ground.

The conclusions derived from the tests were followed in the bridge design. The rails were kept away from the reinforcing steel. It was the intention that the rails should furnish a perfect return circuit across the bridges, and to this end also the rails were double bonded at all joints. As a further precaution, in anticipation of the possibility that some current might leak from the rails to the reinforcing steel and thence into the footings, scrap iron in the form of old car wheels was placed in the ground or rock at the bottom of each footing. The reinforcement was then well grounded to this scrap iron, and this was embedded in pulverized coke.

Loads and Stresses.

The live loading used in the design was the standard bridge loading of the West Penn Rys. Co. based on 9,000-lb. wheel loads. For dead

load computations the reinforced concrete was assumed to weigh 150 lbs. per cu. ft. A horizontal wind load of 40 lbs. per sq. ft. was considered as acting upon the horizontal projection of the bridge structure and also upon a train surface averaging 12 ft. high above the rails for the full length of the bridge.

The 67-ft. span of bridge "B" and the 75-ft. span of bridge "C" were treated as simple beams for the reason that, though the girders extend over the supports, the adjoining girders are not of a size sufficient to warrant the assumption that the long main span girders are continuous. In the 75-ft. span the maximum bending moment to be provided for was 26,078,500 in.-lbs. The maximum negative bending moment at its supports was assumed to be equal to the maximum positive bending moment at the center of the adjacent spans.

Except over the piers at the ends of the long spans, as just noted, the negative bending moments were assumed to be of the same value as the positive bending moment at the center of the longer adjacent span. Sufficient upper fiber reinforcement was, of course, provided to take care of such negative bending moments.

The maximum bending moment to be provided for in the case of the 30-ft. span of bridge "C" was taken to be equal to the maximum moment which would have been developed in the adjacent 25-ft. span under the standard loading. Since the span is an end span and was itself designed as a simple beam the girder sections and reinforcement of the 30-ft. and 25-ft. spans of bridge "C" are identical at span center. An added reason for making the girders of the 25-ft. span of the same depth as those of the 30-ft. span was the symmetry gained by so doing. A similar scheme was followed in designing the 45-ft. and 40-ft. spans of bridge "B."

A continuous upper fiber reinforcement, consisting of two 1-in. bars, was placed in each guard section. Over the piers this upper fiber reinforcement was assumed to take its portion of the negative bending moment. In addition, a sufficient number of the main lower fiber tension rods were bent upward at 45° at various distances from the center of span and were then continued as upper fiber reinforcement over the supports or into the abutment haunches (for the details of which see Fig. 3). A shear diagram was used to determine the position of the stirrups, but the spacing near the supports was increased somewhat over that demanded by the diagram.

In the bridge girder design moments were figured from the standard formula based upon a parabolic distribution of stress in the compression portion of the beam, neglecting the tensile strength of the concrete. The reinforcement used was a high carbon steel with an elastic limit of 60,000 to 64,000 lbs. per sq. in. The proportion of tension fiber reinforcement at points of maximum bending moment is approximately 1.25% of the gross cross-sectional area of the beam. A safe unit stress of 18,000 lbs. per sq. in. for the steel would ordinarily have been allowable. In order to provide for impact stresses, however, a safe unit stress of 14,000 lbs. per sq. in. was actually used and no further allowance for impact was made. According to the above assumptions of stress and stress distribution, therefore, the maximum compressive stress in the concrete is approximately 700 lbs. per sq. in. Above the footing courses a 1:2:4 concrete was used with probable ultimate compressive strength of 3,000-3,200 lbs. per sq. in.

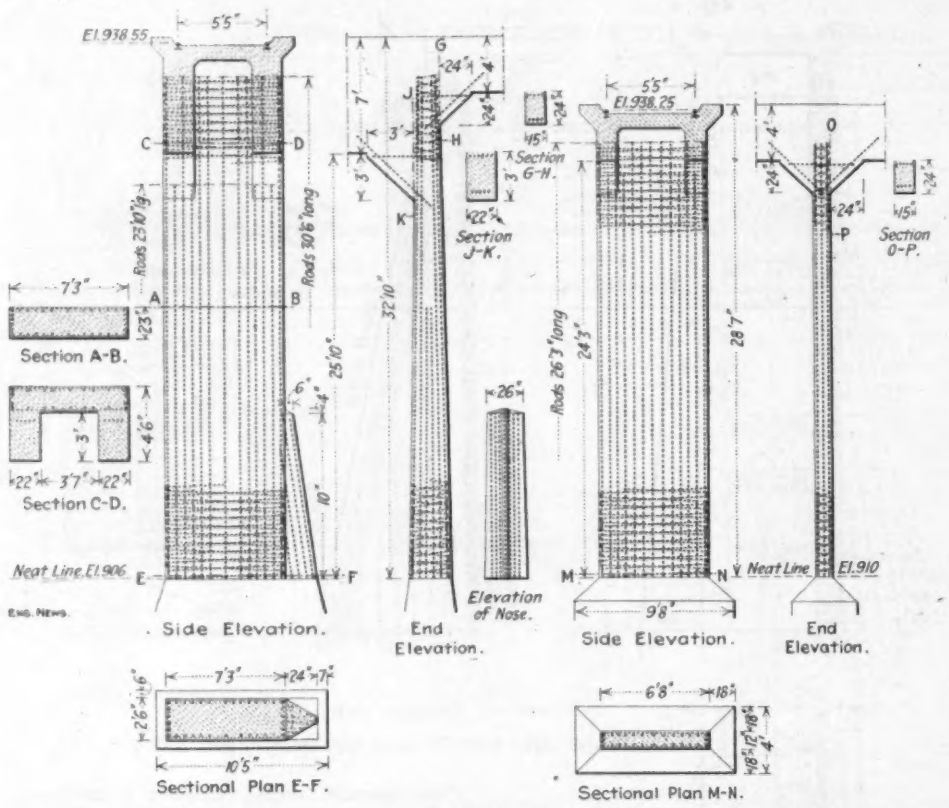


FIG. 5. TYPICAL DETAILS OF PIERS ON BRIDGE "C.," BROWNSVILLE EXTENSION, WEST PENN. RYS. CO.

The following figures as to actual quantity of reinforcing steel are interesting. In bridge "C" girders the reinforcing steel, including stirrups but no deck or bulb beams or T-rails, constitutes 5.75% of the total weight. In the same girders the steel forms 1.76% of the total volume.

Construction.

The concrete work, including the falsework, excavation, formwork, and the furnishing and placing of materials, was let by contract. This same contract included also the fabrication and placing of the reinforcing steel. The steel itself was furnished f. o. b. cars at the bridge sites by the Railways Company.

Fortunately the Brownsville extension parallels and, especially near the sites of bridges "B" and "C," is quite close to the line of the Monongahela R. R. This facilitated the delivery of material to the bridge sites, the longest wagon haul necessary being less than one-eighth of a mile.

Excavation and foundation construction for both bridges were carried on at the same time. The work on the foundations of bridge "C" was begun on July 8, 1907, just two days after the contract for the work had been awarded. The same force carried on the work at both bridges, shifts being made from one site to the other as the progress of the work demanded.

The foundations of both bridges were first completed and then work begun on the piers and abutments of bridge "C." The falsework for the bridge "C" girders was next placed and the girders of bridge "C" cast. While the girder concrete of bridge "C" was setting, the piers and abutments of bridge "B" were built. The falsework was then moved from bridge "C" to bridge "B" site and finally the girders of bridge "B" were cast.

FORMS.—The falsework and formwork for bridge "C" are shown in detail in Fig. 7. For all of the spans 8 × 8-in. yellow pine posts were used with 8 × 8-in × 10-ft. caps and 10 × 12-in. stringers. The spacing of bents averaged 8 ft. The longest posts required were slightly over 23 ft. in length and rested on 8 × 8-in. × 12-ft. sills. The main sills were in turn placed on 8 × 8-in × 4-ft. mud sills. The falsework in Dunlap's Creek was set by cofferdamming one-half of the creek bed at a time.

For the girder forms 4 × 4-in. cross sills were placed over the stringers and stiffening frames of 4 × 4-in. timber were placed at intervals of 4 ft. These frames were fastened across the top by 4 × 4-in. × 16-ft. ties. These ties also carried the plank runways which were used in pouring the girder concrete. The lagging in all cases was of 2 × 10-in. hemlock, surfaced on three sides.

Because of the monolithic construction required in the case of the girders of both bridges, it was necessary that the formwork for each bridge be completed entirely before the pouring of the girder concrete could be begun. Once begun the work of pouring was carried on continuously until completed. In the case of each bridge the time required extended from early in the morning of one day to the afternoon of the following day. Practically the same force of men was used throughout each pouring, though in the case of bridge "B" two shifts of laborers were used for some of the work. The mixing and placing of the concrete were inspected with especial care throughout the whole period of pouring.

MATERIALS.—Allegheny River gravel and sand were used for the piers and abutments, while for some of the foundations Monongahela River gravel and sand (which are not so clean as the Allegheny River material) were used. For the girders, however, ¾-in. crushed limestone screenings and Allegheny River sand were used for the aggregate.

METHODS.—The contractor's plant consisted of one 1-cu. yd. mixer, steam engine driven, and a stiff leg derrick with a 50-ft. boom, with its steam hoisting engine. The derrick was used for the falsework erection and for the pouring of the girder concrete of bridge "C." The concrete in this case was handled from the mixer in bottom-dump steel buckets to the bridge deck, where it was dumped into a large mortar box and rehandled by shovel into wheelbarrows. It was then wheeled along the plank runways to be deposited at the required points.

This mode of placing the concrete was decidedly uneconomical, and at the suggestion of the writer a different scheme was adopted in pouring the girder concrete of bridge "B." The mixing plant in this case was set up on the bluff at the north end of the bridge, practically on a level with the bridge deck. The mixer was set close to the end of the bridge and the concrete was handled in concrete barrows borrowed from the Railways Company, and was then dumped directly into the girder forms. In this way the cost of mixing and placing the girder concrete was reduced from $2.19 in the case of bridge "C" to $1.70 in the case of bridge "B," this despite the fact that bridge "C" was poured during ideal autumn weather, whereas the pouring of bridge "B" occurred during disagreeable winter weather and part of the time during a driving snow storm. The figure for bridge "B" includes also the expense of heating the materials, etc.

Most of the bridge work was carried on during

very favorable weather. The construction of bridge "B" girders, however, as stated above, extended into winter conditions. Special provision was made against freezing of the concrete after pouring. Such precautions proved to have been well taken, for the average temperature during the pouring was in the neighborhood of 20° F. An old stationary boiler was set up at the mixing site to furnish steaming hot water which was fed into the barrel alongside of the mixer hopper. The concrete was poured in a sloppy condition (as also in the case of bridge "C") and was so warm that steam arose from it in the cold air. The pouring completed, the bridge was covered as completely as possible with heavy canvas, which was placed on planks and timber so as to leave an air space between the upper surface of the concrete and the canvas.

After pouring the upper surface of both bridges it was necessary on account of temperature and labor conditions to allow portions of the deck and guard sections to set for from one to three days before the surface concrete and finishing coat could be applied. In the case of bridge "B" after the surface had been finished the canvas cover was in turn covered with manure in order to protect the fresh concrete, and especially the surface coating, against the continued severe temperature conditions.

It is the writer's opinion, based on observation in this and in other cases, that the most effective of the methods used is the placing of canvas over exposed surfaces in such a way as to leave a closed air space between the fresh concrete and the covering. In this way the heat generated by the setting concrete is utilized to promote conditions favorable to proper setting.

For the removal of the forms the weather conditions obtaining at the various stages of the work were allowed to govern. In the case of the piers and abutments of both bridges, the forms were rarely allowed to remain for more than two days after pouring of the concrete. In some cases hardly 24 hours elapsed between the pourings of the concrete and the removal of the forms, followed by the dressing of the concrete surface. The forms of the bridge girders were removed but one week after pouring, thus allowing the dressing of the outer surface before the concrete had become too hard. The forms on the bottoms of the girders and on the interior of the box portion, that is inside of the girders and below the deck, could not be removed until the falsework was taken down.

Centers were struck in each case 30 days after the girders had been poured. For bridge "C" the striking of centers was begun in the smaller spans. After the falsework had been completely removed from underneath the 25 and 30-ft. spans the wedges were loosened under alternate bents of the 75-ft. span falsework. Finally the remaining centers were struck, beginning at the center and working outward toward each end of the span.

The results of the striking of centers were watched carefully by instrument. The following figures applying to bridge "C" are typical also of bridge "B." No deflection could be detected in the girders after the striking of either the 25 or 30-ft. span centers. The striking of the 75-ft. span centers, however, resulted in the following deflections:

	Ft.
North quarter point (average of both girders)	0.010
Center (average of both girders)	0.014
South quarter point (average of both girders)	0.012

Certainly a maximum deflection of less than 3/16-in. under so heavy a dead load is surprisingly low (the bending moment due to dead load in the case of the 75-ft. span being 72% of the maximum bending moment). The deflections at the piers in all cases were zero so far as could be determined.

Continued observation by means of the instrument, however, showed a temporarily increasing deflection in the case of the bridge "C" girders. Eleven days after the striking of centers the following conditions were observed to exist: (a) deflection of center of 75-ft. span had increased

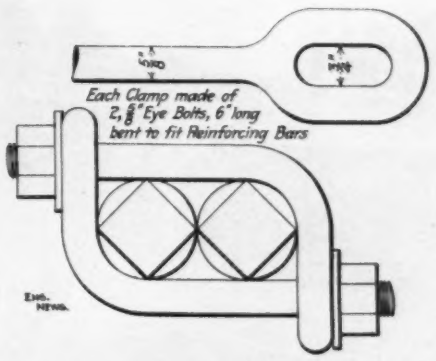


Fig. 6. Splice Clamp for Reinforced-Concrete Bars Used on West Penn. Rys. Co. Bridge Construction.

from 0.014 to 0.032 ft.; (b) no determinate changes on piers or abutments; (c) center of 30-ft. span had deflected upward 0.014 ft.; (d) no change in 25-ft. span girders.

Careful measurements were again made eight months after the striking of centers and the same conditions as given above were found still to exist. This would indicate that the girders did not take their final deflection or set immediately after the striking of centers, but that they did take their final set within a period of eleven days or less thereafter.

Provision was made for embedding the rails by leaving a slot cored out by means of wooden forming. In about a week after the pouring of the girder concrete and the casting of the guard sections the rails were set in the slots and a 1:2½ grout poured around the rails so as to completely fill the slot.

Costs.

The contract price for the 1:3:6 concrete used in the foundations was $8.25 per cu. yd. The corresponding price for the 1:2:4 concrete used in the abutments, piers and girders was $19 per cu. yd. In neither case was the cost of the steel included. The Railways Company delivered all steel to the contractor at the bridge site ready for fabrication.

The actual costs to the contractor were as follows:

	Bridge "B."	Bridge "C."
Foundations (1:3:6)	$7.37	$7.14
Piers and abutments (1:2:4)	13.96	16.26
Girders (1:2:4)	19.50	22.19

The actual unit costs, including the direct expenditures of both the contractor and the Railways Company, were as follows:

Foundation Concrete (1:3:6):

Items.	"B" 27.5 cu. yds.	"C" 39.1 cu. yds.
Testing for foundations	$0.46	$0.20
Excavation	0.64	1.50
Forms—Lumber (no salvage)	0.38	0.38
Concrete—Cement	1.72	1.68
Sand	0.79	0.85
Gravel	1.39	1.38
Mixing and placing	2.09	2.30
Steel—Cost	1.25	0.57
Labor	1.00	0.55
Engineering—Design	1.15	1.15
Inspection	2.54	2.54
Total	$13.41	$13.10

Pier and Abutment Concrete (1:2:4):

Item.	"B" 37.1 cu. yds.	"C" 44.8 cu. yds.
Plant—Rental	$0.68	$1.00
Transportation and erection.	0.71	1.10
Forms—Material	1.06 (1)	1.06 (1)
Labor	2.07	1.82
Concrete—Cement	2.61	2.56
Sand	0.76	0.74
Gravel	1.67 (2)	1.69 (2)
Mixing and placing	3.10	4.39
Steel—Cost	2.38	1.44
Labor	0.81	1.49
Engineering—Design	1.15	1.15
Inspection	2.54	2.54
Total	$19.54	$20.98

(1) Salvage allowed.
(2) Includes cost of haulage, railroad tracks to mixing site.

Girder Concrete (1:2:4):

Items.	"B" 135.0 cu. yds.	"C" 112.0 cu. yds.
Plant—Rental	$0.68	$1.00
Erection	0.71	1.10
*Forms—Material	2.17	2.17
Labor	2.12	2.47
*Falsework—Material	1.25	1.25
Labor	1.51	2.52
Concrete—Cement	2.53	2.53
Sand	1.57	1.28
Stone	2.38	1.96
Mixing and placing	1.70	2.19
Dressing	0.39	0.68
Reinforcing steel—Cost	4.72	4.97
Bending	1.27	1.50
Placing	1.31	1.54
Miscellaneous steel	1.17	0.98
Engineering—Design	1.15	1.15
Inspection	2.54	2.54
Total	$29.17	$31.89

*Salvage allowed.

In computing the plant rentals used above the following values and factors were assumed:

Value of Plant:

Item.	Value.
Concrete mixer, engine and boiler	$1,250.00
Hoisting derrick and engine	1,000.00
Miscellaneous plant	150.00
Total	$2,400.00

Rental Factors:

Interest	0.5% per month
Depreciation	1.1% per month
Total	1.6% per month

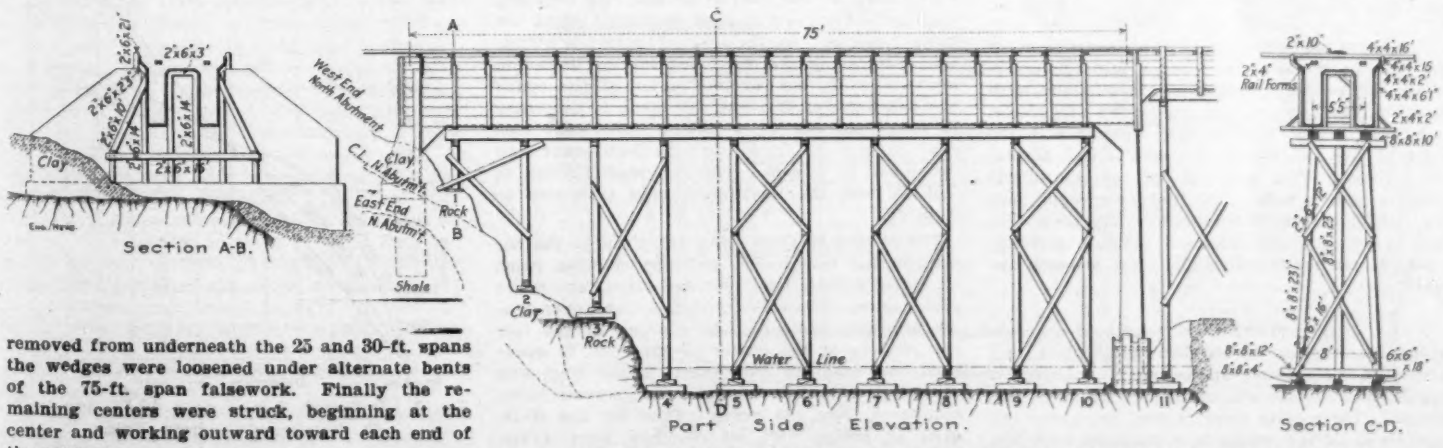


FIG. 7. DETAILS OF CENTERING AND FORMS USED ON THE 75-FT. GIRDER.

The plant was involved for a period of about five months. The item of plant rental as given in the itemized costs above includes repairs and maintenance, but not operation.

From these costs it will be noted that the inspection charge is quite high. It must be expected, however, that on work requiring such care as the reinforced concrete bridge work under discussion, the engineering and inspection costs will run proportionately high.

The cost of girder formwork per sq. yd. of form surface was found to amount in the case of bridge "B" girders to $1.15 and in the case of bridge "C" girders to $1.41. These items include both material and labor.

Inasmuch as standard steel bridges had been designed for both sites "B" and "C" and bids had been received for both concrete work and superstructure, the present case offers an admirable

FIG. 8. LOAD TEST ON THE 67-FT. REINFORCED-CONCRETE GIRDER OF THE BROWNSVILLE EXTENSION, WEST PENN. RYS. CO.

comparison between the cost of reinforced concrete and standard steel construction. The comparison is lessened in value only by the fact that while both types of bridges were designed to meet the same physical conditions, yet the concrete structures are in each case longer than the steel structures were planned to be. Thus at site "B" the concrete bridge is 192 ft. long as against the 100 ft. length in the steel design, and site "C" bridge is 130 ft. long as against the original design for 120 ft. steel bridge.

Under these conditions the costs compare as follows, the reinforced concrete costs being actual and the steel costs based on bids:

	Bridge "B."	Bridge "C."
Reinforced concrete	$5,214.74	$4,840.46
Steel	5,329.98	4,499.24

The items on which no direct comparison of cost can be made did not enter into the above totals and proper corresponding reductions were made in the costs of the respective structures. It is evident that there is little difference in the costs of the two types of construction, despite the extremely high unit cost of the reinforced-concrete girder work. On the other hand once the reinforced-concrete structure has been well built it has the advantage of absolute permanence, cheaper maintenance and more pleasing appearance.

Tests.

In view of the novelty of the reinforced-concrete bridge construction on the Brownsville line, and especially the extreme span length employed, it was deemed advisable to make load tests of these bridges. These tests were carried out under the supervision of the writer in connection with Mr. J. L. Fritsch, Chief Engineer of the West Penn Rys. Co. A work car, shown in Fig. 8, was called into service. This car had an open platform, bare except for the motorman's cab in the center, thus permitting the loading of the car with rails. The rails used were the standard 70-lb. size, and of 33-ft. length. Preparatory to making the test this work car was accurately weighed by a rather unique utilization of rail leverages. Once the weight of the car had been determined any desirable load could be easily obtained by adding the proper number of rails.

The standard loading for which these bridges were designed has been given above. Inasmuch as in the case of the longer spans it was possible to get the whole standard loading, i. e., two cars, upon the span at the same time, it was necessary to compute for the single car that loading which would cause the same bending moment in any particular span as the standard loading. Accordingly a load of approximately 85,000 lbs. (including weight of test car) was necessary for the longest span under test, viz., the 75-ft. span of bridge "C." This required a load of 62 standard rails in addition to the tare of the car. The car itself was especially equipped to take this overload.

On the other hand, in the case of some of the shorter spans a weight actually less than that of the standard loading was used owing to the fact that the test car had a shorter truck spacing than the cars of the standard loading.

The deflection at the center of each span was measured and in the case of the longest spans of both bridges additional deflection measurements were taken at the quarter points. An ordinary engineer's Y-level was used in taking all of the measurements. At the quarter points a standard self-reading rod was used for the deflection measurements, but at the center of the spans the overhang of the test car made it necessary to take readings on a folding rule. The rule read directly to 1/16-in. and the instrument man estimated to 1/64-in. The rod read directly to 0.01 ft. and the instrument man estimated to 0.001 ft.

The results of these tests are given in the accompanying table. The columns showing point of measurement, load and deflection require no explanation. The column headed "load over center of span" indicates the position of the test car relative to the center of the span in question. All readings were taken on the west side of the girders, the four pairs of wheels being numbered from the north. Thus for the 40-ft. span of bridge "B" all readings were taken with the second pair of wheels from the north end of the car directly over the center of the span, etc.

The column headed "Per cent of maximum bending moment" gives the ratio between the bending moment for which the particular girders in question were designed and the bending moment actually caused by the test load. Deflections are given to ten-thousandths of feet. A fourth figure was added to the rod readings in order that they should correspond with the reduced fractional readings on the rule.

The second last column, headed "Proportionate deflection," gives the ratio under the maximum load imposed between deflection at the center of span and the span length. The last column gives the safe allowable deflection in feet, assuming that the ratio of the safe deflection to the span length is 1 : 1,700. The assumed ratio was based on a series of reinforced-concrete beam tests made by the writer and represents a conservative value. As a matter of fact many tests show that a much lower ratio is allowable as representing a safe deflection for reinforced-concrete beams. It should also be noted that this ratio represents the safe allowable deflection at the elastic limit of the steel reinforcement and not necessarily at the point of failure of the beam or girder.

A study of the data obtained shows that the deflections are so small that they are of comparatively little value in forecasting the action of these particular bridges under loads heavier than those actually imposed. The main value of the data, and in fact of the test as a whole, is to show that all of the girders are capable of safely taking a load far in excess of that for which they were designed.

In the cases of only two spans, namely, the north 40-ft. span of bridge "B" and the 75-ft. span of bridge "C," was it found possible to obtain data for plotting load-deflection curves. These curves are shown in Fig. 9. The curve resulting from the 40-ft. span is deceptive in that it is very smooth. However, its curvature is evidently too flat, since if extended it would show a large increase in deflection for a very small increase in load. Such behavior within the range of loading involved is absolutely contrary to the ordinary action of reinforced-concrete beams. The curve resulting from the 75-ft. span, on the other hand, is irregular; yet this curve in its last sweep is undoubtedly quite near the truth.

In order to establish some sort of a criterion for determining the probable behavior of these spans under loadings heavier than those actually used the writer plotted a "compromise" curve, based partly upon the data obtained from this test and partly on the tests of reinforced-concrete beams referred to above. In the absence of more definite data this "compromise" curve was made to take the form of a straight line.

Despite a number of discrepancies appearing in the data, due to the fact that the deflections were so small as to be difficult of accurate measurement, they show a general uniformity of increase in deflection corresponding to increase of load-

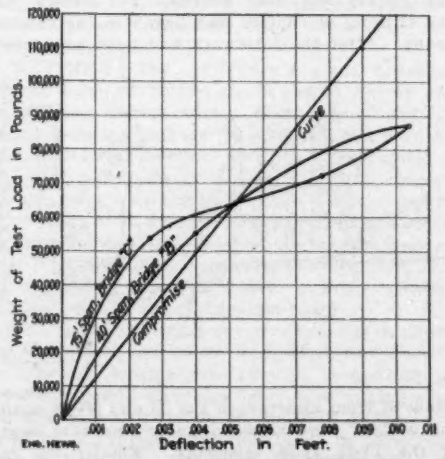


Fig. 9. Deflection Curves on a 40-Ft. and a 75-Ft. Reinforced-Concrete Girder.

ing. Hence the maximum deflections are undoubtedly quite close to the true deflections corresponding to the respective loadings.

It should be noted that on several occasions a considerable overload was applied, amounting in the case of the 40-ft. spans of bridge "B" to 30%, and in the case of the 30-ft. span of bridge "C" to 28% of the designed loading. The action of these particular short spans, with the deflection under the excess load in no case greater than ⅛-in., is sufficient to prove that the longer spans would act in relatively the same way under cor-

TABLE SHOWING TESTS ON WEST PENN RYS. CO. REINFORCED-CONCRETE BRIDGES. JUNE 30, 1908.

Point.	Load in lbs.	*% of Max. bending Mom.	Load over C. of span.	Deflection in feet.	Load in Lbs.	*% of Max. Bending Mom.	Load over C. of span.	Deflection in feet.	Load in Lbs.	*% of Max. Bending Mom.	Load over C. of span.	Deflection in feet.	Load in Lbs.	*% of Max. Bending Mom.	Load over C. of span.	Deflection in feet.	Load in Lbs.	*% of Max. Bending Mom.	Load over C. of span.	Deflection in feet.	Proportionate deflection.	Allowable safe deflection. (Ratio—1/1700)
Bridge B:																						ft.
N 40'—⅛ span....	42,515	64	2d wheel	.0039	54,065	81	2d wheel	.0039	64,075	96	2d wheel	.0052	72,545	108			87,175	130	2d wheel	.0104	1/3840	.0235
45'—⅛ span....	42,515	63	3d wheel	.0078	54,065	80	3d wheel	.0039	64,075	94	3d wheel	.0078	72,545	107			87,175	128	3d wheel	.0052	1/8640	.0265
67'—¼ span....	42,515	52	Car centered	.....	54,065	66	Car centered	.0020	64,075	78	Car centered	.0050	72,545	88			87,175	106	Car centered	.0080	.....	.....
½ span....	42,515	52	Car centered	.0039	54,065	66	Car centered	.0026	64,075	78	Car centered	.0078	72,545	88			87,175	106	Car centered	.0104	1/6432	.0394
¾ span....	42,515	52	Car centered	.....	54,065	66	Car centered	0	64,075	78	Car centered	.0080	72,545	88			87,175	106	Car centered	.0050	.....	.....
S 40'—⅛ span....	42,515	64	3d wheel	.0052	54,065	81	3d wheel	0	64,075	96	3d wheel	.0026	72,545	108			87,175	130	3d wheel	0	.....	.0235
Bridge C:																						
N 75'—¼ span....	42,515	50	Car centered	.0010	54,065	64	Car centered	.0050	64,075	76	Car centered	.0020	72,545	86	Car centered	.0070	87,175	103	Car centered	.0100	.....	.....
½ span....	42,515	50	Car centered	.0050	54,065	64	Car centered	.0026	64,075	76	Car centered	.0052	72,545	86	Car centered	.0078	87,175	103	Car centered	.0104	1/7200	.0441
¾ span....	42,515	50	Car centered	.0030	54,065	64	Car centered	.0070	64,075	76	Car centered	.0050	72,545	86	Car centered	.0080	87,175	103	Car centered	.0100	.....	.....
30'—½ span....	42,515	63	3d wheel	.0100	54,065	80	3d wheel	0	64,075	94	3d wheel	.0026	72,545	107	2d wheel	.0052	87,175	128	3d wheel	.0052	1/5760	.0177
25'—½ span....	42,515	59	3d wheel	.0070	54,065	75	R'd'g impos'ble		64,075	89	3d wheel	.0026	72,545	101	3d wheel	.0052	87,175	121	3d wheel	.0052	1/4800	.0147

These readings inaccurate

*Maximum bending moment above is that live load bending moment which span is designed to take.

respondingly heavier loads. As a matter of fact the deflections in the 67-ft. and 75-ft. spans were comparatively smaller than those obtained for the other spans.

Perhaps the best way to estimate the strength of the bridges is to compare the highest reliable deflections obtained with the deflections which would probably result in the girders just at the elastic limit of the steel reinforcement. This study is shown in the three right-hand columns of the table on p. 91. By comparing the actual deflections for the maximum loads as shown in the table, it is evident that none of the deflections reach or even approach the allowable safe deflection. For instance, the north 40-ft. span of bridge "B" with its excess loading of 30% could deflect more than twice as much as it actually did and still be within the allowable safe deflection. This would show a factor of safety of at least eight (since the safe allowable deflection is itself based on a factor of safety of four). Again in the case of the 67-ft. and 75-ft. spans the deflections under 6% and 3% excess loads, respectively, were only about one-fourth of the allowable safe deflection.

These actual maximum deflections would indicate for the two long spans a factor of safety of about 16. Such factors as apparently shown above are, of course, not reliable because the bridges would undoubtedly fail at lower loadings and hence lower deflections, due to causes other than bending moment. However, the above comparisons show at the very least, that the factor of safety in these bridges is far above actual requirements.

It is interesting to note in this connection that on the same day tests were made of a steel deck truss bridge consisting of three equal spans of 67 ft. 8 ins. The deflections obtained in the case of the steel bridge averaged 1 : 1,714 under a loading equal to approximately 88% of the designed load. The specified allowable maximum deflection of these spans under standard loading was 1 : 2,160.

Both bridges have been in regular service since July 2, 1909. The embedded T-rails are subjected to a severe vibration and are still giving service. However, in so short a period they can hardly be said to have passed beyond the test stage. The action of the decks under snow and ice conditions was looked forward to with interest. The bridges have now passed through one winter in regular service and during that time no hindrance to operation due to snow or ice was encountered.

Passage of the heavy interurban cars over the bridges is without attendant jar or excessive noise. In fact the passing of the cars on or off the bridges is appreciable only by the change in sound of track and bridge vibration. The noise of vibration is considerably less than that of a car passing over a steel bridge, yet the vibration in piers and girders under a moving car is easily detected by the touch of the hand. At the time the tests of the bridges was made the test car with its heaviest load was run over bridge "C" at full speed and even under these severe conditions the effect of impact and the noise of vibration were not excessive.

The reinforcing steel used in the bridge piers and girders were furnished by the Rogers-Shear Co., of Warren, Pa. The bridges were designed and constructed under the direction of the writer. Mr. Victor F. Hammel was Assistant Engineer on both design and construction, while Mr. John G. Ross was Resident Engineer on the construction of bridge "C." To Mr. W. E. Moore, of the West Penn Rys. Co., is attributable the idea of extending the girder sections to act as guard rails and also the scheme of embedding the rails in the concrete deck, both of which worked out very nicely in the design and construction. The contractor for the bridge construction was the Crossan Construction Co., of Philadelphia, Pa.

A New Steam Superheater for Locomotives; Atchison, Topeka & Santa Fe Ry.

The Atchison, Topeka & Santa Fe Ry. is now making somewhat extended use of a new type of superheater which is the invention of Mr. H. W. Jacobs, Assistant Superintendent of Motive Power, and which has been in use for about a year. His corrugated firebox was described in our issue of June 17, and we are indebted to him for plans and information of the superheater.

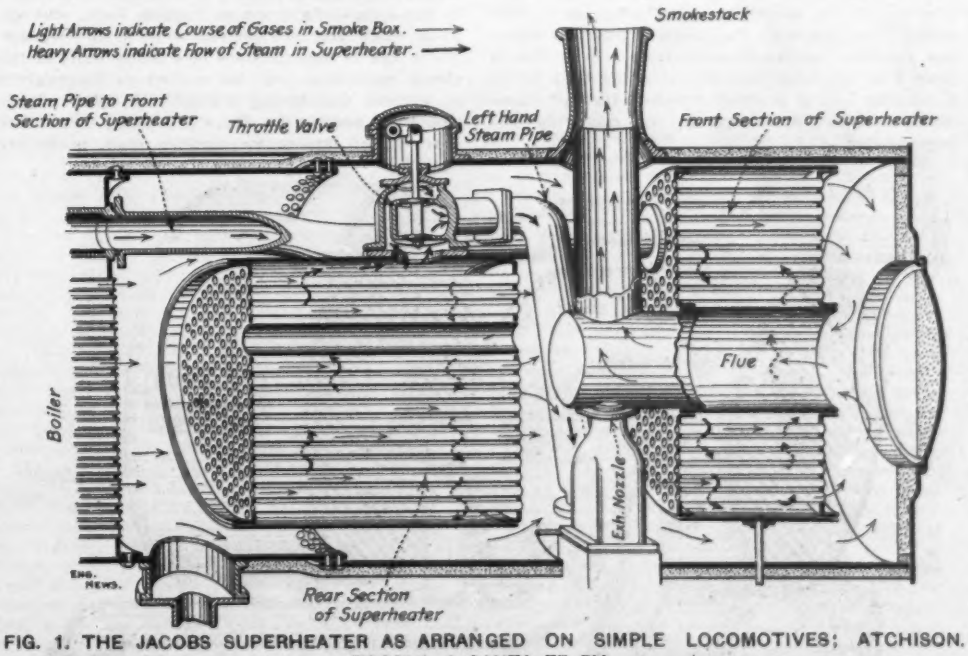


FIG. 1. THE JACOBS SUPERHEATER AS ARRANGED ON SIMPLE LOCOMOTIVES; ATCHISON, TOPEKA & SANTA FE RY.

H. W. Jacobs (Inventor), Assistant Superintendent of Motive Power.

The Jacobs superheater is of the smokebox fire-tube type, involving no changes in the construction of boilers or front ends in its application to locomotives of the usual type. The superheater consists of two steel drums fitted with horizontal fire tubes and having suitable steam connecting pipes. The gases of combustion after leaving the boiler tubes pass through and around the superheater sections, superheating the steam to an average of 100°. The superheating is thus accomplished by utilizing waste heat in the gases of combustion, without sacrificing effective heating surface in the boiler.

The construction and arrangement of the superheater are shown clearly in Fig. 1. The forward drum is circular in cross section and located ahead of the exhaust pipe. The rear drum is somewhat oval in cross section, in order to leave space above it for the dry pipe, and is placed about 27 ins. ahead of the front tube sheet of the boiler. The dry pipe is extended to the back end of the front drum of the superheater, and the steam is caused to circulate around the tubes by baffle plates of thin sheet steel arranged as shown by Fig. 2. The steam passes back from the front drum to the top of the rear drum, where it is again circulated around the fire tubes and the superheating completed. From this latter drum the steam is carried to the steam chests through two vertical steam pipes as shown in Fig. 3. In this view, the front drum is removed, and the two open pipes at the top are for the connections with that drum.

The front section has a large cylindrical opening between the tube sheets, and a smoke tube or flue through this opening connects by an elbow with the petticoat pipe beneath the smokestack. The connections are made with tight joints so that the draft induced by the exhaust causes no direct current from the boiler tubes to the smokestack. The flue gases from the boiler are drawn forward by the exhaust through the tubes of both sections of the superheater, and then back through the cylindrical return flue in the front section, into the draft pipe and out at the smoke-

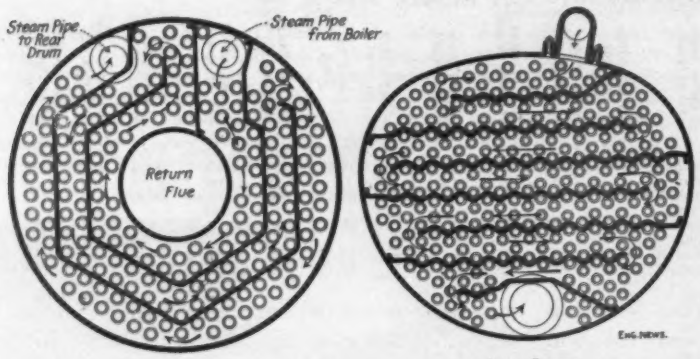


FIG. 2. ARRANGEMENT OF TUBES AND BAFFLE PLATES IN THE DRUMS OF THE JACOBS SUPERHEATER.

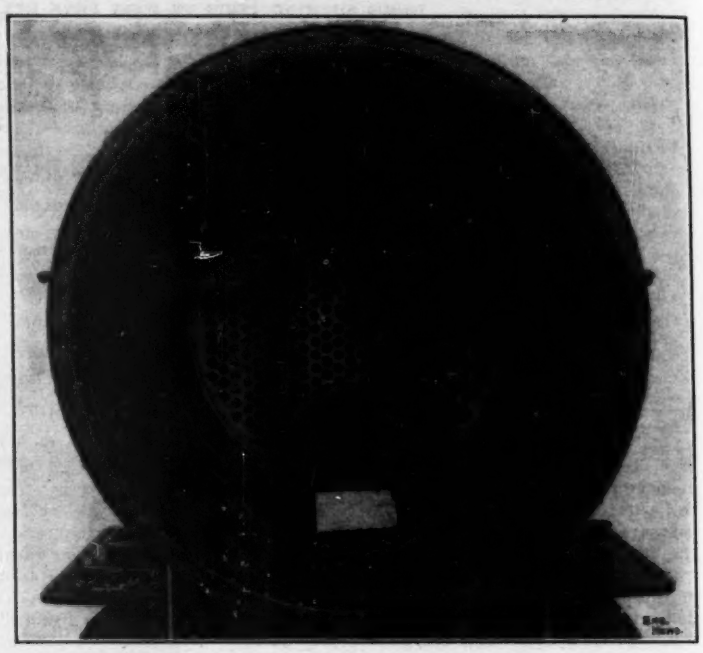


FIG. 3. FRONT VIEW OF REAR DRUM OF JACOBS SUPERHEATER IN POSITION.

The two open pipes at the top are for the connections to the front drum (removed), which occupies the front portion of the smokebox. The two vertical pipes carry the superheated steam to the cylinders, and between them is the exhaust pipe.

stack. Thus the gases are brought into contact with all the superheating surface, and there is said to be secured an equalization of draft in the boiler which is not possible with the usual draft appliances. An even draft is induced in all the boiler tubes and over all portions of the fire, with consequent improved combustion and evaporation. The use of spark netting and a front-end diaphragm is avoided, as in the indirect course followed by the gases through the superheater tubes, live cinders are so broken up and destroyed as to eliminate all throwing of sparks from the smokestack.

The superheater drums are made as light as safety will permit, thus reducing the weight of the superheater to the minimum, and the thin sheets form efficient heating surfaces. The tube ends in the back section are welded to the flue sheets by the autogenous process, thus securing perfect and permanent joints. The tubes in the front section are expanded and beaded in the regular manner. Owing to the thinness of all superheating surfaces, the maximum degree of superheat is quickly reached after the locomotive is started.

For facilitating work on the boiler tubes, the back section of the superheater is located 27 ins. ahead of the flue sheet, providing a working space between the two. A manhole through the lower portion of the smokebox affords access to this space. In line with the large cylindrical opening (or flue) in the front section, a 6-in. flue is placed in the rear section, in order that boiler flues may be cut out and removed through these holes, without the necessity of removing the superheater.

All parts of the superheater are readily accessible, and the drums may be easily removed from the smokebox. Owing to the manner in which the superheater is built, there are practically no running repairs to be made while the engine is in service. The steam pipe connections have ball joints, and with the elimination of all draft appliances, the work on the front end is practically reduced to inspection. While the live cinders are broken up and all fire throwing from the smokestack is eliminated, the front-end is self-cleaning and requires but little attention at terminals on this account.

The first Jacobs superheater was applied to a simple locomotive of the Atchison, Topeka & Santa Fe Ry. which left the shops in November, 1908, and has been in continuous service since that time with absolutely no repairs to the superheater. Since then, and up to September, 1909, 16 locomotives on the same road have been equipped with Jacobs superheaters. All of these were built in the company's shops at Topeka, Kan., and applied while the locomotives were in for repairs. There are 37 superheaters now being built at the shops, and these will be applied to locomotives at present undergoing repairs and other scheduled to be sent to the shops in a short time. The four Mallet duplex locomotives (two passenger and two freight) about to be delivered by the Baldwin Locomotive Works, are equipped with the Jacobs superheater. In addition to these, the superheater has been specified for 76 locomotives of various types recently ordered from the same works. It is also contemplated ordering 75 additional superheaters from the Baldwin Locomotive Works to be applied to the tandem-compound locomotives.

Locomotives to which superheaters of this type have been applied are of the general dimensions given in Table I. The design and construction of the superheaters has been varied according to the design of the different classes of locomotives to which they were applied, and this table gives also the principal dimensions of the superheaters as applied up to the present time.

It will be observed that in addition to equipping simple locomotives, superheaters have been placed on the four-cylinder, tandem-compound locomotives of the 2-10-2 type, which are the largest engines in the world on a single rigid wheelbase. Fig. 4 shows the construction of the superheater as applied to these engines. In this design, the steam receives an initial superheating in the front section and then passes directly to the high-pressure cylinders by pipes connected to the rear sheet of the drum. The steam is discharged from these (as exhaust) into a receiver pipe leading to the bottom of the rear drum, where the steam is reheated, and then passes to the low-pressure cylinders. In this way the device acts as a two-stage superheater.

In actual road service the locomotives equipped with the Jacobs superheater are said to show a remarkable economy in fuel over locomotives using saturated steam, in addition to greater hauling capacity and lower repair costs. Tests conducted last August by the engineer of tests, on the tandem-compound locomotives with and without the Jacobs superheater, show the superior performance of locomotives using superheated steam. The results are summarized in Table No. II. The tests were on the mountain district between Raton, N. M., and La Junta, Colo., the running distance being 81.5 miles. This is a very severe division, with an almost continual ascent from La Junta, and with very heavy grades.

The tests were made on engine No. 901 equipped with the Jacobs two-stage superheater and engine No. 923 not equipped with the superheater. In general the tests showed that in the engine with superheated steam, the fuel consumption averaged less than 21% less than in the engine

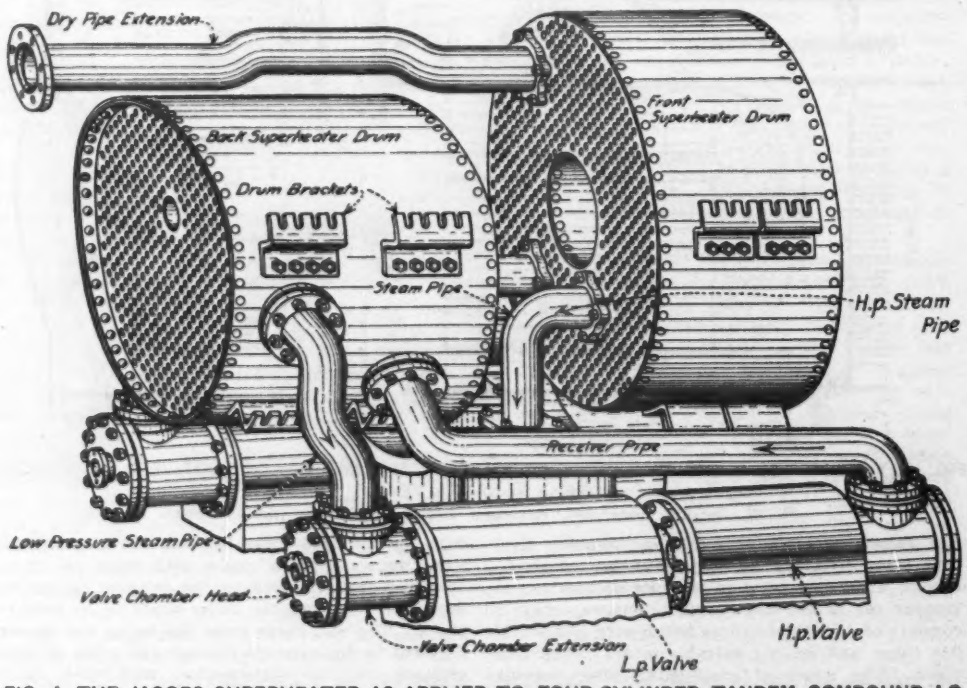


FIG. 4. THE JACOBS SUPERHEATER AS APPLIED TO FOUR-CYLINDER TANDEM COMPOUND LOCOMOTIVES; ATCHISON, TOPEKA & SANTA FE RY.

TABLE I.—LOCOMOTIVES EQUIPPED WITH THE JACOBS SUPERHEATERS: A., T. & S. F. RY.

Type of engine	2-8-0	2-8-2	2-10-2	2-10-0	2-6-2
Simple or compound	Simple	Simple	Tan. comp.	Tan. comp.	Simple
Cylinders, ins.	22 × 32	25 × 32	19 & 32 × 32	.....	25 × 28
Boiler pressure, lbs.	160	160	225	...	160
Driving wheels, ins.	51	57	57	...	69
Weight, on drivers, lbs.	180,440	200,320	252,460	....	141,690
Weight, total, lbs.	202,360	263,400	306,950	...	210,190
Tractive force, lbs.	45,800	47,700	62,800	...	34,700
Front superheater; tubes, No.	501	797	746	388	599
Tubes, diameter, ins.	1½	1½	1½	2¼	1½
Tubes, length, ins.	22⅝	31	31	33	28⅝
Superheater surface, sq. ft.	485.7	824	784	628	586
Rear superheater; tubes, No.	410	371	696	414	501
Tubes, diameter, ins.	1½	2¼	1½	2¼	1½
Tubes, length, ins.	19	25	53⅞	36	21⅝
Superheater surface, sq. ft.	266	472	1,227	764	361
Total superheater surface, sq. ft.	751.7	1,296	2,011	1,392	947
Ratio of superheat, surf. to vol. of cyls. { H.P. cyls.	44.86	71.52	74.65	66.30	59.5
Ratio of superheat, surf. to vol. of cyls. { L. P. cyls.	.....	....	41.20	27.20	....

TABLE II.—TESTS OF TANDEM-COMPOUND LOCOMOTIVES WITH AND WITHOUT THE JACOBS SUPERHEATER: A., T. & S. F. RY. (AUGUST, 1909).

	Superheated steam		Saturated steam	
Engine	901	901	923	923
Tonnage	1,337	1,328	1,250	1,176
No. of cars	48	46	72	64
1,000 ton-miles	109.0	108.2	101.9	95.8
Time on road	6h. 3m.	7h. 0m.	6h.17m.	6h. 6m.
No. of stops	4	10	6	4
Delayed time	1h. 6m.	2h. 7m.	49m.	36m.
Running time	7h.57m.	4h.53m.	5h.28m.	5h.30m.
Water, lbs.	152,400	157,550	168,750	178,400
Coal, lbs.	21,948	22,216	24,717	26,133
Ratio, water to coal	6.96	7.07	6.82	6.83
Coal, lbs. per 1,000 ton-miles	201.3	205.3	244.4	272.9

using saturated steam, and 26% less than in all engines of the same class operating in that territory and not using superheaters. In addition to this, engine No. 901 (with superheater) hauled heavier trains at a higher rate of speed on a less water consumption than engine No. 923, as shown in Table II. An analysis of this table shows that engine No. 901 (with the Jacobs superheater) hauled an average tonnage of 1,332 tons at an average speed of 16.7 mi. per hr. as against 1,213 tons hauled by engine No. 923 at a speed of 14.8 mi. per hr. The locomotive with superheater hauled 9% greater tonnage at a speed 15% higher than the engine using saturated steam. In water consumption per 1,000 ton-miles, engine No. 901 shows a reduction of 18% over engine No. 923, the former using 1,480 lbs. and the latter 1,756 lbs. per 1,000 ton-miles.

The average fuel consumption of engine No. 901 was 203.3 lbs. per 1,000 ton-miles, as against 258.6 lbs. by engine No. 923, which is a reduction of 21% in favor of the locomotive with superheater. In addition to these economies, there is an increased water evaporation per pound of coal obtained in the locomotives equipped with the superheater, due principally to the even draft on the fire produced by the superheater front end. In repairs and operation on the road, the locomotives with the superheater have proved very economical and efficient.

It is stated that the moderate superheat of 100° has been found to be the most satisfactory degree of superheat for locomotive use, as at this temperature practically all of the theoretical advantages of superheat are obtained and there is no deterioration of metal in the cylinders as may be the case with a very high degree of superheating. Experience with the Jacobs superheater in actual service during the past year is considered to have demonstrated its value in improved locomotive performance at reduced cost.

The Development of Traction Engines.*

By W. F. McGREGOR,† Jun. M. Am. Soc. M. E.

The early history of the traction engine goes back to the early history of the steam engine itself. We find that James Watt's attention was called to the possibility of a steam-driven carriage in 1759. He included the locomotive engine in his patent of 1784 and the same year his assistant, one Murdock, made a working model of a locomotive. Wm. Symington, probably the most successful of the early English steamboat builders, was led to turn his attention from a steam carriage to marine work. As early as 1769, a Frenchman, Cugnot, made a three-wheeled, two-cylinder steam carriage which carried four passengers and attained a speed of 2¼ mi. per hr. However it capsized one day in the streets of Paris, which incident led to the imprisonment of the inventor and stopped further trials.

The first record we have of a steam-driven vehicle in America is the patent issued to Nathan Reed in 1790. Also, it is reported that John Fitch, prominent among early American inventors who built steamboats, was working on a steam-wagon design before he began to experiment with boats in 1787. About 1802 Oliver Evans completed a flat-bottomed boat to be used around the Philadelphia docks and, mounting it upon wheels, propelled it by its own steam engine to the river.

About 1830, when the common roads had been considerably improved in England and when railroads were being opened in several places, the idea of the introduction of steam carriages on common highways became popular with inventors. Some of these carriages made regular trips in and around London and were able to attain speeds up to 10 mi. per hr. Opposing legislation and the progress of steam railways prevented a successful development. In America the general roughness of the roads was a great obstacle.

But few traction engines were built during the period from 1840 to 1875, although the patents issued during this time include several devices which are generally supposed to have been first proposed at a much later date. Among these is the "caterpillar" wheel (1856); the four-wheel drive (1857); the traction wheel with spikes which may be withdrawn (about 1859) and the double undermounted engine (1868).

About 1876, when portable engines were used to quite an extent for power for threshing machines, it became apparent that these engines might propel themselves and also perhaps pull the threshing machine from place to place. The manufacture of traction engines was then begun in earnest and in 1880 one finds about ten firms engaged in their manufacture. About 80% of which are still in business.

It was not the writer's intention to dwell long upon history, and that this has been touched at all is merely to get a better appreciation of the present stage of development.

It is well to consider for a moment the engine one would have if all of the desirable features were combined in one. The features would be somewhat as follows:

(1) The fuel consumption must be low, and the fuel should be easily and cheaply obtainable.

(2) The cost of lubrication and miscellaneous supplies must be low.

(3) The ideal traction engine, for all localities, must require a minimum amount of water as there are places where a good water supply is expensive.

(4) The ideal traction engine must be simple and reliable and durable, for maintenance and depreciation must be counted in the cost of power delivered.

(5) There must be no danger of injury to life and property through explosion or fire.

(6) The ideal traction engine must be able to travel over steep hills, sand, gravel, soft ground, sloughs, wet clay, mud, snow, ice, etc., and also to travel on city pavements without injuring them.

(7) It must be able to maintain a constant engine speed, running loaded or light.

(8) The ideal engine would require a minimum amount of attention from the operator either on the road or in the field. The operator must be able to easily steer and operate it and he must be protected from dust and storm.

(9) It must be noiseless.

These requirements, it must be remembered, are for an ideal engine. When several manufacturers build a machine for a certain purpose year after year, they are obliged, to a great extent, to follow the demands of the purchasers and operators, who are naturally most affected by its degree of perfection. It is, in short, in the end simply a matter of the "survival of the fittest." There are many examples in farm machinery, in which the accepted type has become well established. It may then be fairly assumed that the most popular type is the nearest to the ideal. There is still considerable variation in the design of traction engines, of the different manufacturers, but in the case of the steam machine a marked tendency toward a common type is seen. The type with internal-combustion motors, on the other hand, being of more recent origin, naturally show greater variation in design and construction.

To-day, most of the leading builders of both steam and gasoline engines mount the engine on four wheels, the rear two of which are the drive or traction wheels, while the front ones are used to steer the engine. In a few cases a single front wheel is used. The weight is usually distributed so that from two-thirds to three-quarters of it is carried by the traction wheels. A certain amount of weight is necessary on the front wheels so that the engine may be steered when pulling, for the gearing then tends to lift the front wheels from the ground. Four-wheel drive engines have been often proposed and sometimes built, one firm having manufactured them successfully for a number of years.

The differential gear, which allows both wheels to drive all the time independently of the changes in direction of path, is universally used. In practically all of the large engines, the differential gear is located on a countershaft with two sets of gears transmitting the power from the countershaft to the traction wheels. Friction clutches are usually provided to facilitate disconnecting the engine from the traction gearing when desirable for belt power.

For steam machines, use of the locomotive type of boiler has become quite general and, of all the large manufacturers, there are now only three building the return-flue type and of these only one builds it exclusively. Upright boilers and water-tube boilers have been and are still used, but not generally. It is common to mount the engine above the boiler, there being only a few firms who have been or are building undermounted engines. The number of these built is small in comparison with the total number of traction engines. Both one and two-cylinder steam engines are built, a number of the leading firms building both types. Of 16 representative firms which may be considered leading manufacturers, six build the single-cylinder type exclusively and one builds the two-cylinder exclusively. The "live" axle, that is, the system of mounting whereby the traction wheels are placed upon an axle that turns, is gaining ground, and more manufacturers are using it, at least for their larger engines, than ever before.

In valve-gears, the Stephenson link was the favorite at one time, but at present only two or three of the leading firms use it. Simpler valve-gears are more popular. Some form of the radial type is used on over 50% of the engines manufactured and the shifting eccentric is often used.

For belted machinery, it is desirable that there shall be a slight increase of speed at full load to compensate for slippage. Throttling governors are universally used and are satisfactory in this action. Automatic cut-off governors have been used on agricultural engines in Europe, but rarely here. These points are mentioned as indicating the tendency towards certain designs by the leading manufacturers of traction engines, nearly half of whom have now been in the business over 30 years.

This is also concretely shown by a study of 108 engines built by 15 leading makers. The following tabulation results:

	Sizes of each make.	Ratio of stroke to bore.	Normal engine speed.	Piston speed, ft. per. min.	Rate of travel, miles per hr.
Minimum	2	1.00	200	246	1.67
Maximum	12	2.18	300	557	2.63
Average	7	1.313	240.6	423.5	2.239

There are a few traction engines which differ quite widely from the accepted type, but these have, as a rule, been built for some particular class of work and are not usually conceded to be suitable for general use in various localities. Among these are the Best and Holt engines which are built on the Pacific coast, primarily for hauling combined harvesters, but are also used to some extent for plowing, working the soil and for hauling logs, ore, etc. These engines are quite large, some being rated at as high as 110 HP. When required, the boilers furnish steam for an auxiliary engine to drive the header and traveling thresher. Although built for similar purposes, these two makes differ considerably in construction. One has an upright boiler while the other has a horizontal boiler; one has a single engine while the other has a double type; and one is chain-driven while the other has gears. Both ordinarily use crude oil for fuel. Both use a single front wheel and have traction wheels of large diameter (7 to 9 ft.) with wide tires, widths of 4 or 5 ft. being common. One of these manufacturers has built special engines with the traction wheel-tires 13 and 16 ft. wide.

Another example of an engine built for a special purpose is the Lombard, made in New England. This engine is of the double under-mounted type with locomotive boiler. In place of the usual traction wheels it has the so-called "caterpillar wheels," and in place of the front wheels it has runners. It is used to haul logs on snow or ice roads in the woods and the exhaust of the engine is thrown down on to the road where it freezes and renews the ice, making it unnecessary to sprinkle the road as is done when hauling by horses.*

Any discussion of present types of traction engines should make some reference to the relative merits of steam and internal-combustion motor drives. The author cannot attempt to show which is nearer the ideal. It is difficult to take into account all factors, and indeed

*From a paper presented before the annual convention of the American Society of Agricultural Engineers at Ames, Iowa, Dec. 28, 1909.

†Mechanical Engineer of the I. J. Case Threshing Machine Co.

[*A similar logging locomotive has been used near Leech Lake, Minn. These were described in Engineering News, March 14, 1907.—Ed.]

in many cases the personal element of the operator is the deciding factor in determining the reliability, durability, cost of attendance and maintenance, its safety and ability to travel over bad ground.

Fuel cost is always an important item, except where it is straw or refuse of no value otherwise. The internal-combustion engine is capable of higher efficiency than the steam engine, but that is ordinarily of little interest to the purchaser. It is the actual cost of fuel, per unit of power delivered at the belt or drawbar, that is of vital importance to him. It is difficult for the purchaser to fairly compare the figures of several machines because of lack of uniformity in popular conceptions of the unit of power and in the ratings given by the makers. Steam traction machines have been rated at from half to a quarter their actual horse-power while internal-combustion types have been rated more closely to the actual capacity. Most makers publish only the nominal rated horse-power, although some publish both nominal and actual and a few publish only brake horse-power. Ordinarily a purchaser has no means of applying the Prony brake test so that a uniform rating based on cylinder dimensions, pressure and piston speed is desirable.

The Association of Licensed Automobile Manufacturers have adopted a simple horse-power formula as a ready reference guide. It has been possible to reduce this formula to the simplest condition, because American practice in automobile-motor construction is quite uniform. This formula is simply

$$HP. = \frac{D^2 \times N}{2.6},$$

where "D" is bore of cylinder in inches and "N" is the number of cylinders.

This is based on the assumption of a piston speed of about 250 ft. per min., of a mean-effective pressure of some 90 lbs. per sq. in. and a mechanical efficiency of about 75%, all of which approximate American practice in this line, with sufficient accuracy to serve the purpose for which the formula was intended.

As the practice is not so uniform among the builders of traction engines, either steam or internal combusion, it is not possible to use such a simple formula.

A simple formula useful to most purchasers or operators of such machines may be deduced from the recognized formula:

$$HP. = \frac{PLAN}{33{,}000},$$

Where "P" = mean effective pressure; "L" = length of stroke; "A" = area of piston; "N" = number of power strokes. The quantities are expressed in the usual terms of pounds, square inches, feet and minutes. With usual types of steam engines, where the mean effective pressure is about half the boiler pressure and with a mechanical efficiency of 90% we can rewrite the standard formula as

$$B.\ HP. = \frac{18\ P\ L\ D^2\ N}{10{,}000{,}000}$$

Where "P" is boiler presure in pounds per square inch; "L" is length of stroke; "D" is bore of cylinder; "N" is number of revolutions per minute. This is for one cylinder, of course. With double engines the result should be multiplied by two. The claimed and test brake horsepowers of 25 engines of 17 makes were compared with the results of calculations by this formula. The results generally agreed within a reasonable deviation, say 4%.

A similar formula for internal-combustion motors can be derived, assuming the figures of the A. L. A. M. formula for mean effective pressure and mechanical efficiency. The piston speed cannot be eliminated, however, as this varies in the motors attached to traction engines. The formula for one cylinder of a four-stroke cycle motor is then:

$$B.\ HP. = \frac{66\ L\ D^2\ N}{1{,}000{,}000}.$$

Where "L" is the length of stroke in inches, "D" is the diameter of the cylinder in inches, and "N" is the number of revolutions per minute. In horizontal engines the ratio of stroke to bore is often considerably increased from the value found with vertical cylinders (1.5 compared with 1.0). This longer stroke gives a higher efficiency so that it is necessary to increase the constant 66 given in the preceding formula. The author uses 75 for such machines, making the formula then,

$$B.\ HP. = \frac{75\ L\ D^2\ N}{1{,}000{,}000}.$$

These formulas, applied to the conditions stated, give acceptable results. For vertical engines the formula in the cases studied seems to show a capacity from 3 to 50% in excess of public brake tests. The deviation in the case of horizontal engines is insignificant. It would perhaps be better to use a formula common to all types of gasoline engines in place of changing the constant if one sufficiently simple and accurate can be found. However, it is not these particular formulas that the writer wishes to urge and they are simply suggested as something that might do. The writer does wish to suggest that something be done towards the adoption of some kind of a uniform system of rating traction engines.

A Comprehensive Sewer System for Kansas City, Mo.

By JEAN BART BALCOMB.*

Ever since Kansas City assumed the proportions of a modern and rapidly growing metropolis, the Department of Engineering of the Board of Public Works has known one of the vital needs of the city to be a comprehensive sewer system, in accordance with which all extensions might be built. Like many cities of the middle West, additional sewers have been planned and built to meet exigencies. Necessarily, as the system stands to-day, it is both inadequate and lacking in coordination.

When the present City Engineer, Mr. James L. Darnell, was appointed to the place, he resolved that such an evident need should no longer be ignored. A brief study of the needs and local conditions enabled him to outline the requirements of a comprehensive system. He then planned a department to have charge of the necessary studies and, ultimately, of the designing and construction work. In order to obtain the best possible results, he secured the services of Mr. George W. Fuller, of the firm of Hering & Fuller, New York City, as Consulting Engineer. The writer was placed in charge of the work and preliminary studies were commenced in May of this year.

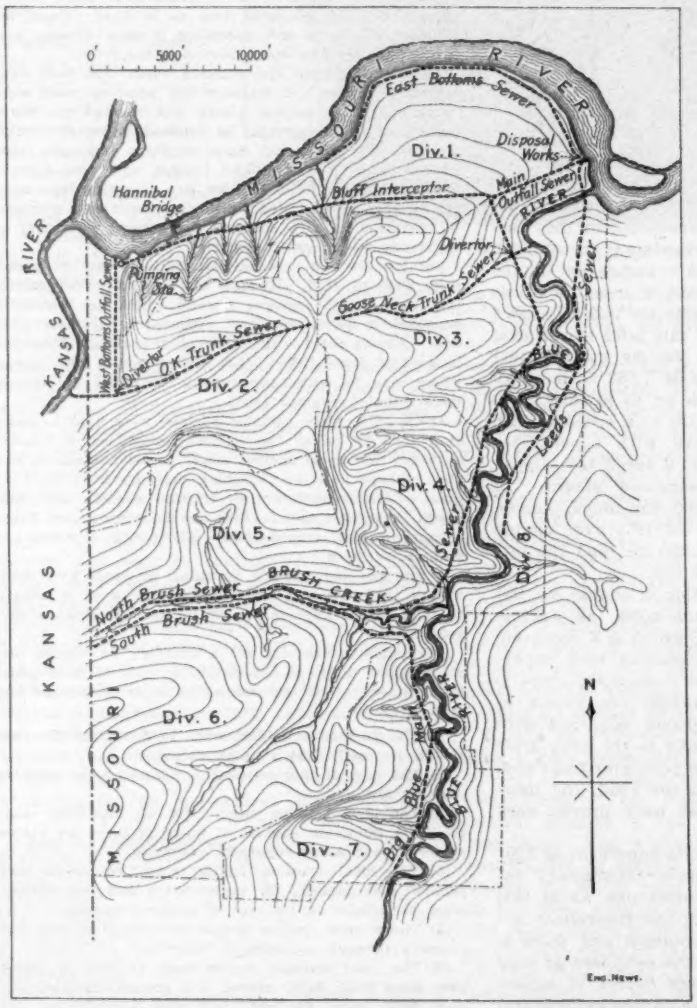


FIG. 1. TOPOGRAPHIC MAP OF KANSAS CITY, MO., SHOWING PLAN OF COMPREHENSIVE SYSTEM.

A large amount of topographical work had already been done and was being platted with a view to covering the entire city by a series of topographical maps. Kansas City is exceptional in having unsurpassed drainage facilities and a diversified topography rarely equaled by cities of its present and prospective magnitude. This at once determines the general location of ultimate disposal works and trunk sewers. The work naturally divides itself into three parts—planning, designing and constructing.

PLANNING.—By reference to Fig. 1, it will be seen that the entire natural drainage of the city reaches the Missouri River at the mouth of the Blue. This makes some location near Point Y on the Government harbor line a desirable site for ultimate disposal works. If necessary, they can be placed nearer to the bluff, or anywhere along the Blue between the junction of Goose Neck and its own junction with the Missouri. At slight additional expense, they might even be placed beyond the Blue, anywhere along the south side of the Missouri River.

It will be noted that the city is divided into a north and south portion by Brush Creek, which also drains a considerable area in Kansas near the State Line. The north portion of the city is again practically divided by Goose Neck and O. K. creeks. As a dividing line running nearly north and south, when the city shall have extended its present boundaries farther east, the Big Blue determines the natural drainage. It will thus be seen that the topography suggests trunk sewers along the Missouri and the Blue rivers, also along Brush, Goose Neck and O. K. creeks.

However, at present the population and manufacturing interests in the East Bottoms are not of sufficient magnitude to warrant the construction of a trunk sewer there, and most of the region on the bluff is well cared for by the present system and the Grand Ave. pumping station. There is a very great need, however, for increased facilities in the West Bottoms. This, together with the fact that ultimately it will be desirable to run a high line Bluff interceptor to serve Divisions 1 and 2, makes it advisable to construct a West Bottoms outfall sewer, at the same time building a pumping station to discharge the flow during times of flood, and which can later be utilized to pump the sewage into the Bluff interceptor, when an outfall sewer shall have become objectionable at this point.

In all probability, it will be found necessary to run trunk sewers along both the east and west banks of the Blue. Studies are in progress to determine whether or not this will also be wise in the case of Brush Creek. The writer is of opinion that it will be found more economical and convenient to construct sanitary mains both north and south of the creek, rather than on either bank, thus obviating the frequent crossings which would otherwise be necessary.

Owing to Divisions 2 and 3 being already well built up, and therefore supplied with the combined system, the O. K. and Goose Neck trunk sewers will probably carry both storm and sanitary flow, the sanitary being diverted at the locations shown on Fig. 1.

The plan for storm runoff is to utilize Brush Creek, the Blue, the Kaw and the Missouri rivers as open streams, discharging into these at the earliest practicable moment; while the ultimate plan for the sanitary sewage (whenever federal or state laws, or the growth in public sentiment,

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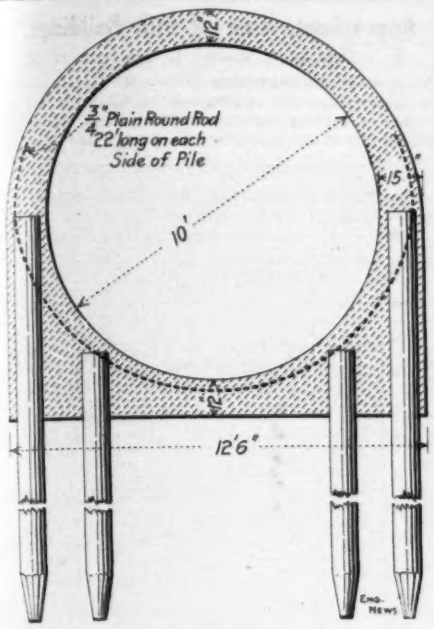

Fig. 2. Standard Section of 10-Ft. Sewer.

shall demand it), is to conduct the entire amount to a point near the junction of the Blue and the Missouri rivers and there treat it by dispersion, filtration, or whatever method at that time seems most feasible and desirable. Wherever the present sewers are inadequate, they will be supplemented by storm drains. In the new territory the separate system will be used exclusively.

DESIGNING.—Preparatory to the design of a system, it was deemed necessary to have topographic maps of the entire city, and these are practically complete at the present time. In order to estimate the amount of sanitary sewage, the present and prospective population of the different parts of the city are being determined, and also the water consumption. That we may rationally determine the size of storm drains, a number of rain gages have been installed in different parts of the city to supplement the reports of the Weather Bureau. They were placed in operation at the beginning of September. A number of weirs are to be constructed on the different small streams and several automatic gages placed in existing sewers, as an added means of determining the amounts of storm water and of sanitary sewage. For the purpose of designing outfalls, it is planned to prepare hydrographs of the Blue and the Kaw, and of the Missouri both at Hannibal Bridge and Point Y on the harbor line.

Precipitation records are being compiled, not only of rains in this city, but in other cities throughout the Mississippi drainage basin, from which curves are being prepared in order that we may develop a composite precipitation curve for Kansas City, closely approximating actual conditions. Studies are being made also of the perviousness of the soil both in virgin territory and in built-up areas.

ORGANIZATION.—To facilitate the accomplishment of these ends, the department is being organized into different bureaus, as follows: The Bureau of Surveys, under the direction of a Chief Surveyor, having in charge all surveying and level work, and the gathering of data relative to materials in excavation. The Bureau of Hydraulics, under the direction of a Chief Hydrographer, having in charge the gathering of data relative to precipitation and to the flow in creeks and sewers. The Bureau of Records, under the direction of a Chief Compiler, having in charge the gathering of all information from the city records, other public records, private records and human sources generally; also having in charge the records of this department. The Bureau of Designs, under the direction of a Chief Draftsman, having in charge the preparation of all maps, plans, profiles and other drawings. The Bureau of Estimates, under the direction of a Chief Estimator, having in charge all estimating work, including the preparation of specifications. The Bureau of Inspection, under the direction of a Chief Inspector, having in charge all construction work, whether by contract or day labor.

CONSTRUCTION.—The O. K. trunk sewer, the West Bottoms outfall sewer, and the north and south Brush Sanitaries are already greatly needed. Work is now in progress on the West Bottoms outfall, and every effort will be made to begin construction on the others before the close of the present season.

Fig. 2 is a cross-section of the West Bottoms sewer; Fig. 3 is a plan, and Fig. 4 sections, showing the method of flood protection adopted.

The difficulties that have had to be overcome are due to, (a) the excessive scour of the river in times of extreme flood, (b) the buoyancy of the sand and silt when thoroughly saturated, producing a tendency to float, (c) the heavy earth loading the sewer will carry when the West Bottoms are brought up to grade, which will eventually be at elevation 32.

Flood protection is accomplished by three features:

(1) The sewer itself is reinforced.

(2) It is supported laterally by a box-shaped bulkhead on the down-stream side, having reinforced roof, floor and walls.

(3) The piles are encased in a 2-ft. concrete wall down to a point below the minimum stage reached by the river during the past 30 years.

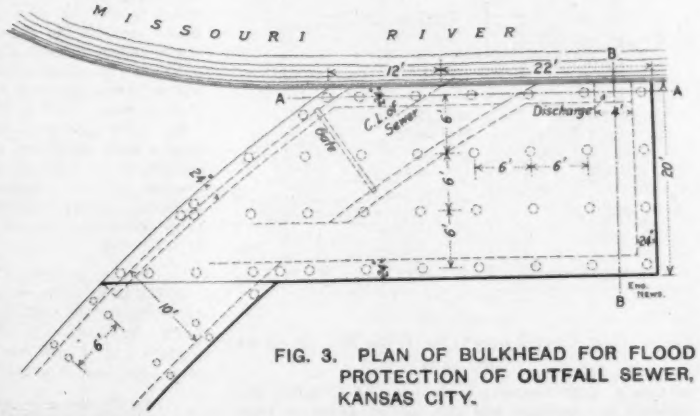

FIG. 3. PLAN OF BULKHEAD FOR FLOOD PROTECTION OF OUTFALL SEWER, KANSAS CITY.

The bulkhead is to be utilized also as a compartment, where a centrifugal pump will be operated by motor in the pump house above, so as to discharge the sewage during times of flood.

The usual form of concrete sewer construction is departed from, in that practically no reinforcement is employed and the sewer is being built monolithic in section. The rods shown, which are firmly anchored to the piles, are more for the purpose of joining them securely to the concrete than for reinforcing the sewer at the haunches, although it will strengthen the concrete in case it should be subjected to tension. The writer, however, sees no possibility of tensile stresses except such as will be produced by future live loads; even these being largely distributed by the earth covering, and dissipated so far as the sewer is concerned.

The maximum capacity is 850 sec.-ft., with a velocity of slightly less than 11 ft. per sec. Its entire length is about 1,000 ft., joining the Henning, Santa Fe and Armour sewers and the proposed West Bottoms interceptor.

The writer is of opinion that great good will accrue to the engineering profession, by discussing important works during construction, as well as after completion, and so offers the foregoing at the present time.

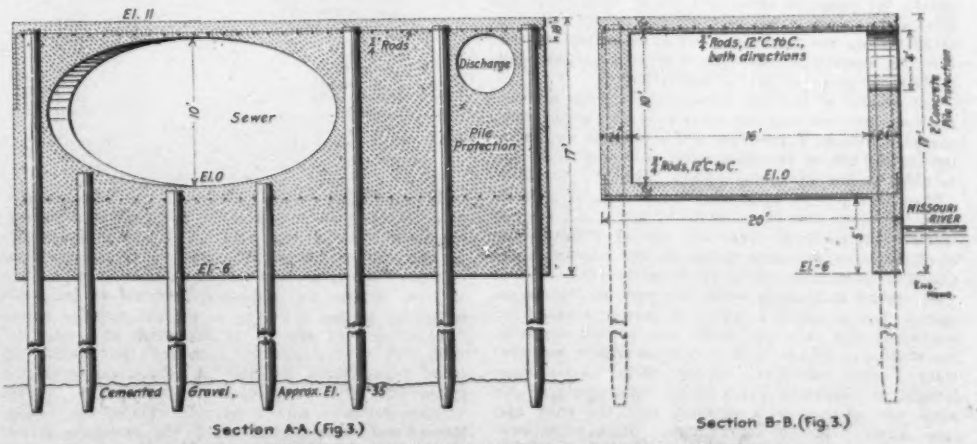

FIG. 4. SECTIONS THROUGH OUTFALL SEWER BULKHEAD.

The Deep Well System of Water Supply for South Bend, Ind.*

By ALONZO T. HAMMOND.†

A supply of pure water from deep or artesian wells is a valuable asset of many cities of Indiana, and the one city peculiarly favored is South Bend. Many of the cities which have depended on their deep well supply for a number of years, have found the flow gradually decreasing, the effective head growing less, placing a greater burden on the pumps for a suction lift, in many cases requiring some type of deep-well pump to force the water from a depth below the limit of suction of the piston pump, and requiring the drilling of new wells over a wider field. It is particularly true that the static head has become less, and the field is fertile for the air lift and for the centrifugal or screw pump which can be put into a small well casing.

The wells found along the St. Joseph River in northern Indiana have a strong hydrostatic pressure, those in South Bend particularly so. Heavy deposits of gravel are found at and near South Bend and along the river channel an average vertical section penetrating the water bearing gravel may be as follows, this being a vertical section of a 10-in. well drilled in 1906 at the central station. There is 14 ft. of top soil, then 59 ft. of impervious blue clay of a fine texture, which has been largely used in the manufacture of building and paving brick, burning white. Below the clay is 9 ft. of compact sand, and then 28 ft. of coarse gravel which is water bearing, making a total depth of 110 ft. The actual depths and thickness of the different strata vary widely and the total depths vary from 85 ft. to 125 ft.

The source of water supply to this stratum of gravel has been conjectural, one assumption being that it is supplied from gravel deposits lying northeast from the city; another, that its source is the river, the percolation going on at some point well up the river from South Bend. It is barely possible that the latter theory is correct and that the stratum leading to the one at South Bend is very limited in extent, because of the fact that numerous borings a few miles above have so far failed to locate any similar supply of water. The following data as to the static head of the wells indicate a gradual dropping off of hydrostatic pressure as the location of the wells is carried downstream. At Springbrook Park, about two miles above the Central station

*Abstract of a paper read at the annual meeting of the Indiana Engineering Society, at Indianapolis, Ind., Jan. 14.

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(this station is within one block of the business center of the city) the static head of a 2-in. well is at an elevation of 32 city datum. At the Central pumping station, the static head is 28; at the North pumping station, which is about 3,000 ft. below the Central, the static head is 27; at Terrace Ave., which is the lower city limits, the static head in a test well was 22, and at St. Marys, three miles below the Central station, the static head is 4 city datum. This shows a total drop of 28 ft. in head within the five miles, which to my mind indicates a source of supply from the east and possibly the river as that source.

The gravel in which the well points stop is very coarse, carrying some sand, but it is believed to be sufficiently open and porous to permit of a relatively high rate of flow. The blanket of impervious clay not only prevents possible contamination of the supply but protects and maintains the pressure from below.

The limit of width of the water-bearing gravel is not well defined, as sufficient wells have not been drilled to outline the limits on each side of the river, but during some recent tests at the Central station when the head in the wells was pulled down much below the normal level, some influence was felt at two wells, one located east of the river and the other west, being about 3,000 ft. apart.

If this width of gravel should be maintained for the full length of the river within the city limits, with an average depth of gravel at 20 ft., a storage capacity for water is provided in this gravel bed of 3,000,000,000 gallons of water.

The first pumping plant, placed in operation in 1873, pumped river water, but it was later discovered that the station site was underlaid with this artesian supply of water, and by 1886 some 25 wells were drilled, using 4-in. and 6-in. pipe. Some difficulty was had with water coming up between the clay and the pipe as the pipes were pushed through the clay stratum, but an outer casing was adopted, driven into the clay some 15 or 20 ft. and the annular space plugged.

The number of wells at the Central station has been increased, so that now there are in use nine 4-in. wells, fourteen 6-in., four 8-in. and six 10-in. wells. The wells vary in depth from 110 ft. to 125 ft.

The supply being limited by the small ground area owned by the city at the Central station, a new station site was obtained within the city limits and about 3,000 ft. downstream from the old station, and a contract made in 1895 for the drilling of 30 wells 6 ins. in diameter. These wells have an average depth of 85 ft. and the screens project into the gravel about 12 ft.

The first three wells were located about 70 ft. apart and the water from the first well drilled flowed about 11 ft. above the ground and some 20 ft. above the river at a normal stage. A test was made at the time of the flow of the first five wells, the first three being 70 ft. apart and the last two being 100 ft. apart.

The test on each well with the others not flowing was from 462,240 to 588,380 gals. per day, as shown by a weir measurement, the rate of flow being for 24 hours and the flow due to the natural hydrostatic head or pressure. Another test of flow was made to determine the influence of the wells on each other and a loss on well No. 1 of 30% is noted when the adjacent wells are all open over what its flow was when they are all closed. The test indicates that the direct influence on each other of the 16 wells located within the reservoir (within an area of about 3,600 sq. ft.) is very great, and the results of the tests show an exceedingly great dropping off of the average flow due to such influence.

During 1908, in order to test the condition of the 16 wells at the Central station, a small piston pump was attached to the individual wells and the pump speeded up until the vacuum gage on the pump read up to about 25 ins. with results of 95,000 to 406,000 gals. per day.

The arrangement of suction mains is such at the Central station that a 2,500,000-gal. pump may be (and usually is) connected direct with the 20 wells (four outside) and at times it has been difficult to pull a vacuum of 22 ins. on the large pump when so connected. The variation extends perhaps from 4,600,000 gals. per days to 2,500,000 gals. per day, or nearly 46%.

The results of the test showed three wells as nonproducers and one well had its valve closed, which, when opened, developed a good flow and a valuable well. After the cutting out of the three wells there was a marked decrease in the air in the suction main.

There are certain advantages in the use of a 10-in. pipe, but there does not seem to be any direct ratio of increase of discharge from the use of different size pipes, the flow depending rather on the velocity in the gravel stratum of the water reaching the pipe.

No system of locating wells was used at the central station; it was merely a matter of putting a hole down somewhere and expecting water with a high pressure; the effort was successful only because nature had provided a rich reservoir. At the north station some thought was evidently given to the relationship of the wells, but an idea was advanced that the river had some direct influence on the flow. Some wells were placed in the river and the most of the others parallel to and along the bank of the river, while the pumphouse was set some distance away, requiring long suction mains, and small pipes were used to too large an extent in connecting up the suction mains.

The wells were put down with an outer casing extending into the clay; the screens were about 12 ft. long and the well pipe was extended up to the surface and capped, the lead to the suction main having a valve at each well.

With thirty 6-in. wells and four 10-in. wells, a volume of water at the rate of 9,000,000 gallons per day has been pumped for short periods, but this reaches about the limit with the present layout.

The static head has not been materially reduced during the last 15 years, and possibly not at all, as the head shown in 1895 was 11 ft. above the surface of the ground and at a point near the river, while the head measured a year ago was 9 ft. above the surface measured at a well nearer the pump-house. The prospect of a continuance of a very efficient supply from this stratum of gravel is so good that the field will be further developed with new wells.

The real difficulty is the lack of reservoir capacity in the small wells to take care of emergency pumping when all the pumps must be worked up to their capacity, and at such times the head runs off quite rapidly. To provide against such a contingency, I have recommended the construction of a deep concrete reservoir near the pumps and to form a link in the suction line; the mains leading from and connected to the wells would be carried to the bottom of the reservoir at such a depth as to be entirely below the limit of suction of the pumps and the intake pipe would draw from the same low level.

During a cessation of pumping or when there is a normal load the reservoir would stand full of water and

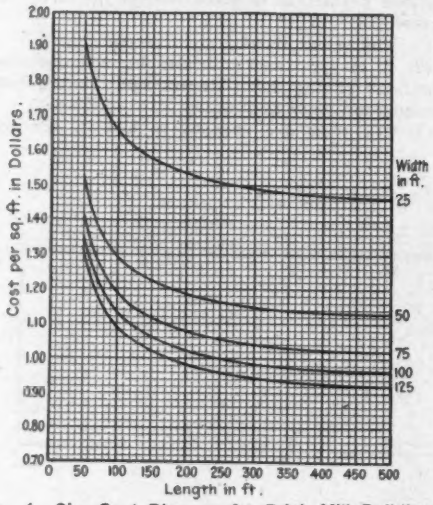

Fig. 1. Size-Cost Diagram for Brick Mill Buildings; One-Story.

provide a large storage; a reservoir of 1,000,000 gals. capacity was designed and this volume would be ample to care for any sudden draft as for fires or heavy pulls during the dry season for sprinkling.

The water has, of course, a fairly uniform temperature and being free from any source of contamination, the most strict requirements are met as a potable water for domestic use; it is also very satisfactory for commercial uses, as shown by the following recent analysis:

	Parts in 100,000
Odor	None
Color	0.0
Turbidity	None
Sediment	None
Free ammonia	.3514
Albuminoid ammonia	.0054
Nitrates	None
Nitrites	.0002
Chlorine	1.4
Total solids	36.6
Fixed solids	29.8
Hardness	24.6
Iron	.001
Colon bacili	Absent
Lead	None

NATURAL-GAS UTILIZATION in the United States, according to press reports from the Geological Survey, increased in value from $215,000 in 1882 to $54,640,374 in 1908, an increase of 253 times the value of original output. The capture and sale of natural gas thus seems to have become an established industry—an indication borne out by the extension of the gas districts in the Appalachian field and by the beginnings of a large development of the mid-continent and Gulf fields. In 1908, Pennsylvania led the 22 natural-gas producing states with a value of product of $19,104,944. West Virginia followed with a value of $14,837,130. Ohio, Kansas and Indiana came next. The remaining states' production was valued at less than $1,000,000 each.

Approximate Cost of Mill Buildings.*

By CHARLES T. MAIN,† M. Am. Soc. M. E.

It is sometimes convenient to be able to tell off-h[and] the approximate cost of proposed buildings, or the c[ost] if new, of existing buildings without going through [an] estimate of all the quantities of materials and labor. [It]

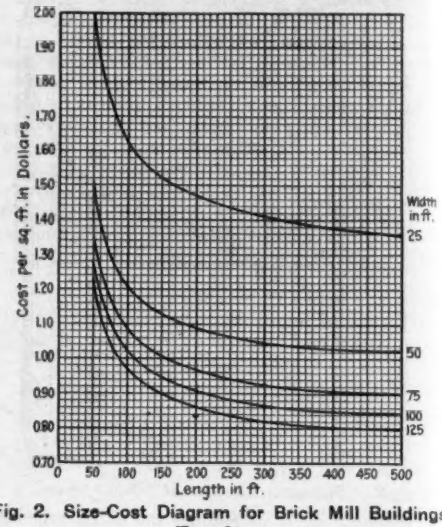

Fig. 2. Size-Cost Diagram for Brick Mill Buildings; Two-Story.

is not an uncommon thing to hear the cost of mill buildings placed from 70 cts. to $1 per sq. ft. of floor space, regardless of the size or number of stories. There is, however, a wide range of cost per square foot of floor space, depending upon the width, length, height of stories and number of stories.

Some time ago, I placed a valuation upon a portion of the property of a corporation, including some 400 or 500 buildings. In order to have a standard of cost from which to start in each case, I prepared a series of diagrams showing the approximate costs of buildings varying in length and width and from one story to six stories in height. The height of stories also was varied for different widths, being assumed 13 ft. high if 25 ft. wide, 14 ft. if 50 ft. wide, 15 ft. for 75 ft., 16 ft. for 100 ft. and over.

The costs used in making up the diagrams are based largely upon the actual cost of work done under average conditions of cost of materials and labor and with average soil for foundations. The costs given include plumbing, but no heating, sprinklers, or lighting. These three latter items would add roughly 10 cts. per sq. ft. of floor area.

Use of Diagrams.

ESTIMATES.—The accompanying diagrams can be used to determine the probable approximate cost of proposed brick buildings, of the type known as "slow-burning" to be used for manufacturing purposes, with a total floor load of about 75 lbs. per sq. ft. and these can

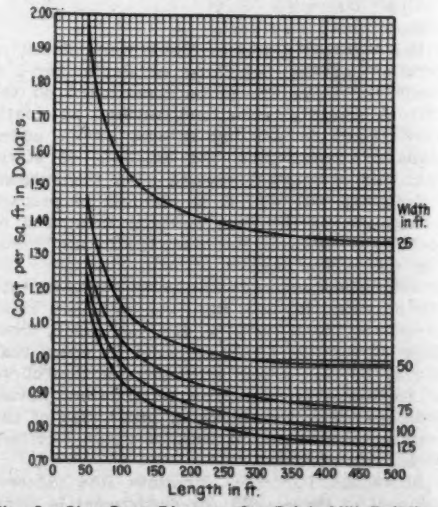

Fig. 3. Size-Cost Diagram for Brick Mill Buildings; Three-Story.

be taken from the diagrams readily. The curves were derived primarily to show the estimated cost per square foot of gross floor area of brick buildings for textile

*A paper, presented before the New England Cotton Manufacturers' Association, April, 1904, revised to conform with prices prevailing about January, 1910.

†Mill Engineer and Architect, 201 Devonshire St., Boston, Mass.

mills, and to include ordinary foundations and plumbing. For example, if it is desired to know the probable cost of a mill 400 ft. long by 100 ft. wide, three stories high, refer to the curves showing the cost of three-story buildings. On the curve for buildings 100 ft. wide, find the point where the vertical line of 400 ft. in length cuts the curve, then move horizontally along this line to the left-hand vertical line, on which will be found the cost of 81 cts.

The cost given is for brick manufacturing buildings under average conditions and can be modified if necessary for the following conditions:

(a) If the soil is poor or the conditions of the site are such as to require more than the ordinary amount of foundations, the cost will be increased.

(b) If the end or a side of the building is formed by another building, the cost of one or the other will be reduced slightly.

(c) If the building is to be used for ordinary storage purposes with low stories and no top floors, the cost will be decreased from about 10% for large low buildings, to 25% for small high ones, about 20% usually being a fair allowance.

(d) If the buildings are to be used for manufacturing purposes and are to be substantially built of wood, the cost will be decreased from about 6% for large one-story buildings, to 33% for high small buildings; 15% would usually be a fair allowance.

(e) If the buildings are to be used for storage with low stories and built substantially of wood, the cost will be decreased from 13% for large one-story buildings, to 50% for small high buildings; 30% would usually be a fair allowance.

(f) If the total floor loads are more than 75 lbs. per sq. ft. the cost is increased.

(g) For office buildings, the cost must be increased to cover architectural features on the outside and interior finish.

The cost of very light wooden structures is much less than the above figures would give. Table I. shows the approximate ratio of the costs of different kinds of buildings to the cost of those shown by the curves.

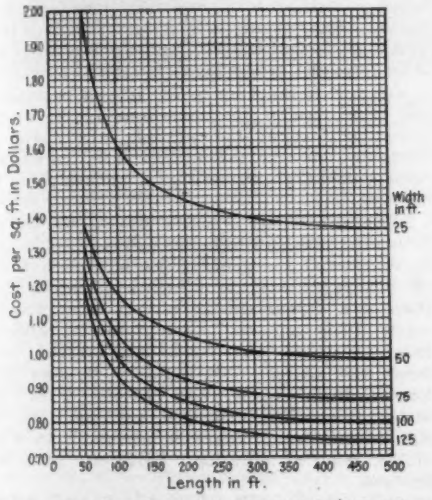

Fig. 4. Size-Cost Diagram for Brick Mill Buildings; Four-Story.

EVALUATIONS.—The diagrams can be used as a basis of valuation of different buildings.

A building, no matter how built nor how expensive it was to build, cannot be of any more value for the purpose to which it is put than a modern building properly designed for that particular purpose. The cost of such a modern building is then the limit of value of existing buildings. Existing buildings are usually of less value than new modern buildings for the reason that there has been some depreciation due to age and that the buildings are not as well suited to the business as a modern building would be.

Starting with the diagrams as a base, the value can be approximately determined by making the proper deductions.

The diagrams can be used as a basis for insurance valuations after deducting about 5% for large buildings to 15% for small ones, for the cost of foundations, as it is not customary to include the foundations in the insurable value.

Use of Tables.

Table II. shows the costs which form the basis of the estimates and these unit prices can be used to compute the cost of any building not covered by the diagrams. The cost of brick walls is based on 22 bricks per cubic foot, costing $18 per thousand laid. Openings are estimated at 40 cts. per sq. ft., including windows, doors and sills.

Ordinary mill floors, including timbers, planking and top floor with Southern pine timber at $40 per M. ft. B. M. and spruce planking at $30 per M., costs about 32 cts. per sq. ft., which has been used as a unit price. Ordinary mill roofs covered with tar and gravel, with lumber at the above prices, cost about 25 cts. per sq. ft. and this has been used in the estimates. Add for stairways, elevator wells, plumbing, partitions and special work.

Deductions from Diagrams.

(1) An examination of the diagrams shows immediately the decrease in cost as the width is increased. This is due to the fact that the cost of the walls and outside

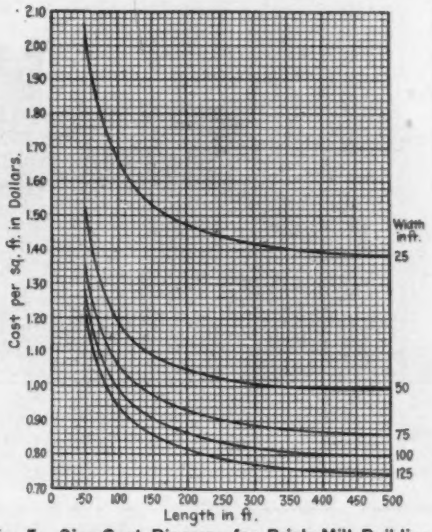

Fig. 5. Size-Cost Diagram for Brick Mill Buildings; Five-Story.

foundations, which is an important item of cost, relative to the total cost, is decreased as the width increases.

For example, supposing a three-story building is desired with 30,000 sq. ft. on each floor:

If the building were 600 ft. × 50 ft., its cost would be about 99 cts. per sq. ft.

If the building were 400 ft. x 75 ft., its cost would be about 87 cts. per sq. ft.

If the building were 300 ft. × 100 ft., its cost would be about 83 cts. per sq. ft.

If the building were 240 ft. × 125 ft., its cost would be about 80 cts. per sq. ft.

(2) The diagrams show that the minimum cost per square foot is reached with a four-story building. A three-story building costs a trifle more than a four-story. A one-story building is the most expensive. This is due to a combination of several features:

(a) The cost of ordinary foundations does not increase in proportion to the number of stories, and therefore their cost is less per square foot as the number of stories is increased, at least up to the limit of the diagram.

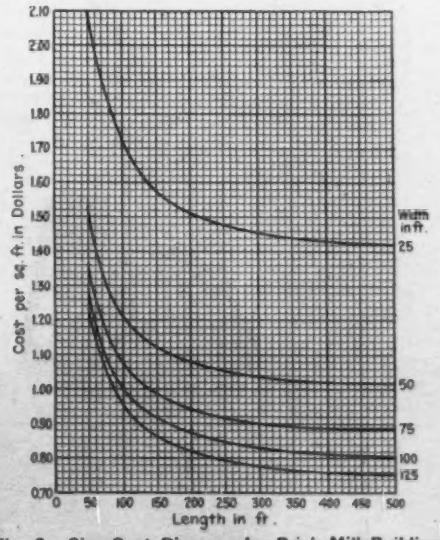

Fig. 6. Size-Cost Diagram for Brick Mill Buildings; Six-Story.

(b) The roof is the same for a one-story building as for one of any other number of stories, and therefore its cost relative to the total cost grows less as the number of stories increases.

(c) The cost of columns, including the supporting piers and castings, does not vary much per story as the stories are added.

TABLE II. DATA FOR ESTIMATING COST OF BUILDINGS.

	FOUNDATIONS including excavations. Cost per lin. ft.		BRICK WALLS. Cost per sq. ft. of surface.		Columns including piers and castings.
	for outside walls.	for inside walls.	outside walls.	inside walls.	Cost of one.
One Story Building,	$2.00	$1.75	$ .40	$ .40	$15.00
Two " "	2.50	2.25	.44	.40	15.00
Three " "	3.80	2.80	.47	.40	15.00
Four " "	4.70	3.40	.50	.43	15.00
Five " "	5.60	3.90	.53	.45	15.00
Six " "	6.50	4.50	.57	.47	15.00

(d) As the number of stories increases, the cost of the walls, owing to increased thickness, increases in a greater ratio than the number of stories, and this item is the one which in the four-story building offsets the saving in foundations and roof.

(3) The saving by the use of frame construction for walls instead of brick is not as great as many persons think. The only saving is in somewhat lighter foundations and in the outside surfaces of the building. The floor, columns, and roof must be the same strength and construction in any case.

ASSUMED HEIGHT OF STORIES.—From ground to first floor, 3 ft. Buildings 25 ft. wide, stories 13 ft. high. Buildings 50 ft. wide, stories 14 ft. high. Buildings 75 ft. wide, stories 15 ft. high. Buildings 100 ft. wide, stories 16 ft. high. Buildings 125 ft. wide, stories 16 ft. high.

Floors, 32 cts. per sq. ft. of gross floor space not including columns. If columns are included, 38 cts.

Roof, 25 cts. per sq. ft., not including columns. If columns are included, 30 cts. Roof to project 18 ins. all around buildings.

Stairways, including partitions, $100 each flight. Allow two stairways, and one elevator tower for buildings up to 150 ft. long. Allow two stairways and two elevator towers for buildings up to 300 ft. long. In buildings over two stories, allow three stairways and three elevator towers for buildings over 300 ft. long.

In buildings over two stories, plumbing $75 for each fixture including piping and partitions. Allow two fixtures on each floor up to 5,000 sq. ft. of floor space and add one fixture for each additional 5,000 sq. ft. of floor or fraction thereof.

(Note: From the above data the approximate cost of any size and shape of building can be estimated in a few minutes. After the cost of the items given is determined about 10% should be added for incidentals.)

TABLE I. RATIO OF COST OF VARIOUS BUILDINGS TO THAT OF BRICK MILLS, STANDARD CONSTRUCTION.

Superficial feet of Floor in one story	FRAME MILLS						BRICK STORE HOUSE						FRAME STORE HOUSE					
	1 Sto.	2 Sto.	3 Sto.	4 Sto.	5 Sto.	6 Sto.	1 Sto.	2 Sto.	3 Sto.	4 Sto.	5 Sto.	6 Sto.	1 Sto.	2 Sto.	3 Sto.	4 Sto.	5 Sto.	6 Sto.
1250	.86	.67					.80	.73					.70	.51				
2500	.86	.73					.85	.73					.75	.58				
5000	.89	.78	.75	.73	.70	.67	.83	.80	.78	.76	.76	.75	.74	.60	.56	.53	.51	.48
7500	.90	.79	.77	.74	.71	.69	.85	.81	.78	.77	.76	.76	.77	.63	.58	.55	.53	.51
10000	.90	.80	.78	.75	.73	.70	.87	.81	.79	.78	.77	.76	.78	.65	.60	.57	.55	.53
15000	.91	.82	.79	.77	.75	.72	.89	.83	.81	.79	.78	.78	.81	.67	.64	.61	.59	.56
20000	.92	.83	.81	.79	.77	.74	.90	.84	.82	.80	.80	.79	.82	.70	.67	.64	.61	.59
25000	.92	.85	.82	.80	.78	.76	.91	.85	.83	.82	.81	.80	.83	.72	.69	.66	.63	.61
30000	.93	.86	.84	.81	.80	.77	.91	.86	.84	.82	.81	.81	.84	.73	.70	.67	.65	.62
35000	.93	.87	.84	.82	.80	.78	.92	.86	.84	.83	.82	.81	.85	.74	.71	.68	.66	.63
40000	.93	.87	.85	.83	.81	.79	.92	.87	.85	.84	.83	.82	.86	.75	.72	.69	.67	.64
45000	.94	.87	.85	.83	.82	.79	.92	.87	.85	.84	.83	.82	.86	.76	.72	.70	.67	.65
50000	.94	.88	.86	.84	.82	.80	.92	.88	.86	.84	.83	.83	.87	.77	.73	.71	.69	.66

Reinforced-Concrete-Buildings.

From such estimates and proposals as I have been able to get and from work done it appears that the cost of reinforced-concrete buildings designed to carry floor loads of 100 lbs. per sq. ft. or less would cost about 25% more than the slow-burning type of mill construction.

Alternate Method of Estimating Cost.

FLOORS.—38 cts. per sq. ft. of gross floor space. This price will include column piers, column, castings and wrought iron.

ROOF.—30 cts. per sq. ft., including projection, say 18 ins., including columns, etc.

STAIRWAYS AND ELEVATOR TOWERS.—Allow two stairways and one elevator tower in buildings over two stories high up to 150 ft. long. Allow two stairways and two elevator towers up to 300 ft. long. Allow three stairways and three elevator towers over 300 ft. long.

BRICK WALLS.—Enclosing stairs and elevators, estimated as inside walls.

STAIRS.—$100 per flight, per story.

PLUMBING.—Allow two fixtures on each floor up to 5,000 sq. ft. of floor space, and add one fixture for each additional 5,000 sq. ft. or fraction thereof. Allow $75 per fixture.

INCIDENTALS.—Add about 10% for incidentals.

TABLE III. DATA FOR APPROXIMATING COST OF MILL BUILDINGS OF KNOWN SIZE BUT WITHOUT DEFINITE PLANS MADE.

HEIGHT OF BUILDING.	FOUNDATIONS. Including excavation. Cost per lin. ft.		BRICK WALLS. Including doors and windows. Cost per sq. ft. of surface.	
	outside walls.	inside walls.	outside walls.	inside walls.
One Story,	$2.00	$1.75	$ .40	$ .40
Two Stories,	2.50	2.25	.44	.40
Three "	3.80	2.80	.47	.40
Four "	4.70	3.40	.50	.43
Five "	5.60	3.90	.53	.45
Six "	6.50	4.50	.57	.47

A Large Elevator Dredge for Work in Boston Harbor.*

The unusually large elevator dredge shown in the accompanying illustrations is now in operation deepening the entrance to Boston Harbor. Elevator dredges have been comparatively little used in the past on harbor work in the United States. Their use in this country has been largely confined to rivers and canals and to gold-dredging operations, but in Europe they have been much more widely used and with good success. The work in the entrance to Boston Harbor covers a large area and excavation is required to a depth of 35 ft. below the low water level. This means that at high tide the dredging must be done at a depth of about 50 ft. The Daly & Hannon Dredging Co., of Ogdensburg, N. Y., which has the contract for this work, had been, for many years, executing all their work with dipper dredges, but in this case, on account of the depth and the exposure to rough weather, it was decided that a sea-worthy elevator dredge of large capacity would be more apt to give satisfactory results.

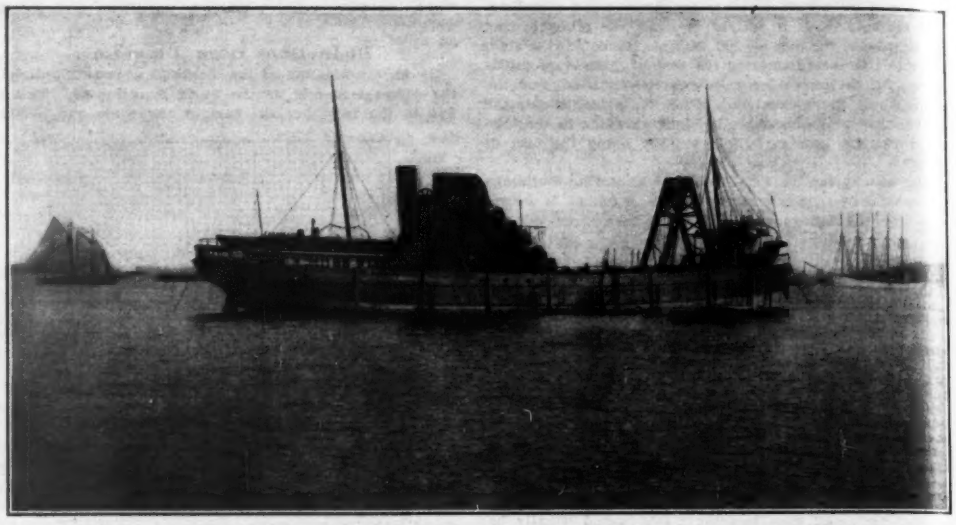

FIG. 1. ELEVATOR DREDGE "DENVER," AT WORK IN BOSTON HARBOR.
(Maximum possible working depth is 51 ft.)

HULL.—To meet these requirements, the dredging machinery was installed in a heavily built wooden cargo steamer originally intended for service on the Great Lakes. The contractors were fortunate in obtaining a vessel with oak frames and planking in perfectly sound condition and of a quality not generally available nowadays for shipbuilding. This vessel (Fig. 1), whose former name, the "Denver," has been retained, is 242 ft. long with 36-ft. beam and a depth of 21½ ft. The "Denver" is self-propelling, with engines of 700 HP., and should be able to cross the ocean if necessary. The work of reconstructing the hull and installing the dredging machinery was done by the Daly & Hannon Dredging Co. in its own yards at Ogdensburg, N. Y.

FIG. 2. THREE LINKS OF THE BUCKET CHAIN OF THE ELEVATOR DREDGE "DENVER."
(Capacity of each bucket is 1¼ cu. yds. Chain runs, when dredging, at the rate of 14 buckets per minute.)

DREDGING MACHINERY.—The dredging machinery was built by the Atlantic Equipment Co. from the designs of Mr. A. W. Robinson, M. Am. Soc. C. E., of Montreal. The form of the buckets† is shown in Fig. 2, which gives also some idea of their size. All parts subjected to heavy wear are of manganese steel. The capacity of each bucket is 1¼ cu. yds. and the bucket chain is driven ordinarily at a rate of 14 buckets per minute, so that the dredging capacity with full buckets would be 1,100 cu. yds. per hour. This has been exceeded by more than 30% for short periods in actual use. For driving the bucket chain, a double tandem compound steeple engine is provided, with cylinders 12 ins. and 16 ins. by 18-in. stroke. This is entirely separate from the engines for driving the vessel's propeller shaft.

The ladder frame is of steel and is of sufficient length to work at a depth of 51 ft. The steel gantry for raising and lowering the digging end of the ladder can be seen in Fig. 3 just behind the pilot house at the bow of the boat.

METHOD OF OPERATION.—The dredged material is discharged through a hopper and chute, shown in Fig. 3, into scows of 1,800 cu. yds. capacity alongside. A sea-going tug is required in attendance to tow the scows to the dumping place and to advance from time to time the anchors which hold the mooring lines of the dredge. There are two bow and two stern lines from the dredge attached to heavy anchors set out a suitable distance, the position of each of which is marked by a buoy. A continuous feed over the bottom is obtained by means of steam winches acting on the mooring lines, and by a special arrangement these lines are held at some depth under the water so as not to interfere with the navigation of the tugs and scows. In this way a width of channel up to 700 ft. can be made at one time. All of the operations of the dredge, including that of the winches, are under the control of one man through levers in the elevated control house, shown in Fig. 3, amidships on the delivery side.

RESULTS.—After a year's service, the buckets with their pins and bushings are reported in good condition and the general loss of time and cost of repairs is said to compare favorably with that of a dipper dredge on the same class of work. The material encountered at different parts of the channel included hardpan, clay, stone and gravel. The ordinary yardage for a single day's work was about 8,000, and under favorable conditions as much as 10,800 cu. yds. was dredged in one day. In a run of 55 minutes duration, 1,475 cu. yds. were dredged.

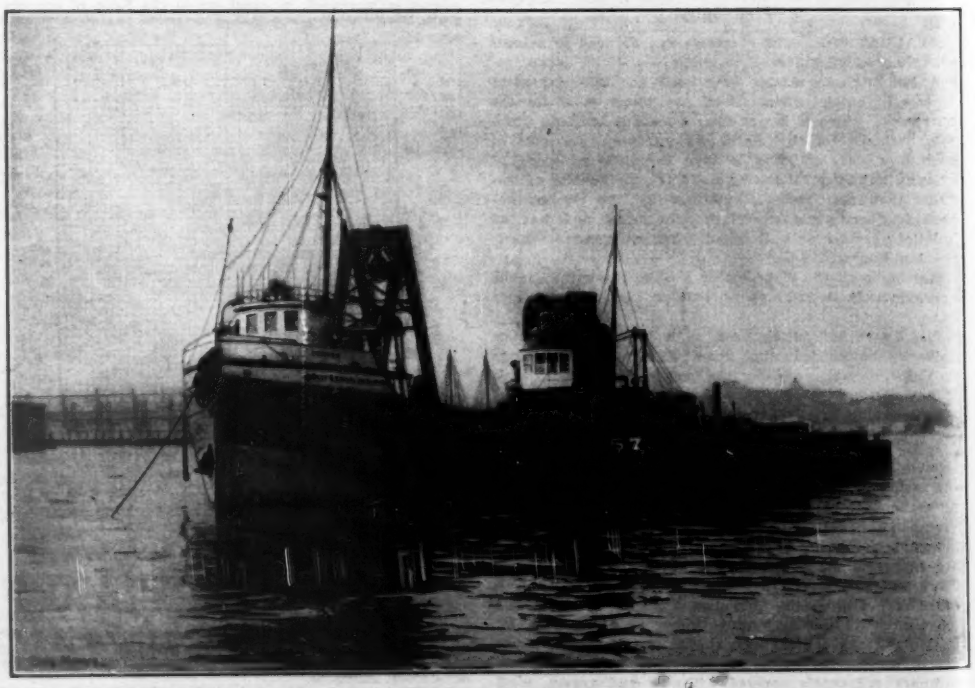

FIG. 3. PORT SIDE OF THE DREDGE "DENVER"; SHOWING THE CONTROL HOUSE AND THE CHUTE FOR DISCHARGING DREDGED MATERIAL INTO SCOWS.

*From information furnished by the Atlantic Equipment Co., 30 Church St., New York City.

†Details of construction of the buckets and tumblers of a similar though smaller dredge designed by A. W. Robinson were described in Eng. News, Nov. 1, 1906, p. 450.

A New Gyroscopic Monorail Car.

Running cars on a single rail with the aid of gyroscopic apparatus to keep the car upright has engaged the attention of two inventors working independently. The work of Mr. Louis Brennan in England was first reported a few years ago (see Eng. News of May 30, 1907, p. 598), but he has progressed more recently from a very small model car to one of regulation railway size (see Fig. 1 herewith).

At the same time a German newspaper publisher, Mr. August Scherl, took up the problem of balancing a single-rail car by gyroscopes in connection with ideas he developed on a new scheme of laying out and operating railways, which he described in a recently published book. Engaging the necessary engineering and mathematical talent, he has built a car of rather more than model size, and after exhibiting it in Germany has recently brought it to this country. The car is shown in Fig. 2, from a photograph taken in Germany.

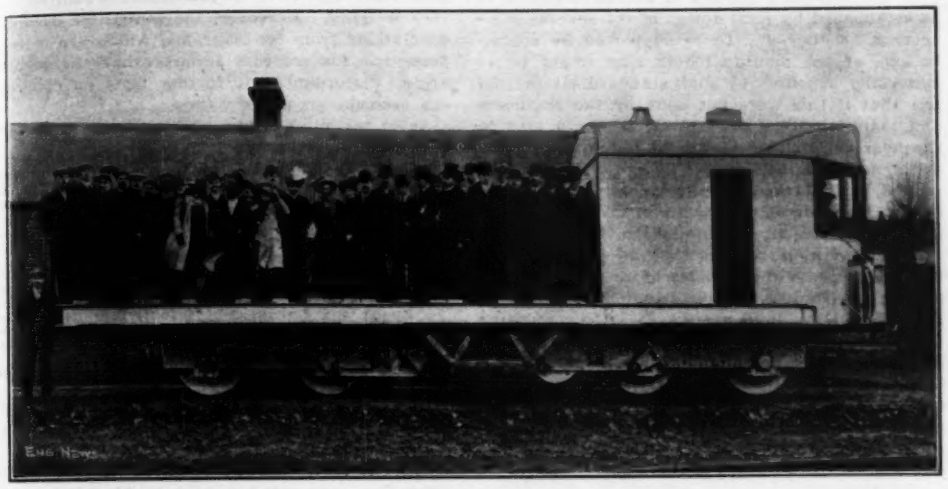

FIG. 1. THE BRENNAN MONORAIL CAR.
(From an illustration in "The Engineer" of London.)

The two cars are identical in fundamentals, and probably not very different in mechanical application of the basic principles. Both carry two gyroscope wheels, rotated in opposite directions, and both rotate these wheels in a vacuum to save power. We understand that these two features are patented by Brennan, and used under license from him in the Scherl car. Scherl uses horizontal gyroscope wheels, i. e., their shafts are placed vertical. Brennan's earlier car, we believe, was described as having gyroscopes with shaft horizontal, though the present picture, Fig. 1, suggests that the vertical-shaft arrangement may be used.

At a recent inspection of the Scherl car (Fig. 2) in New York City, where it has been on exhibition, the following main constructive features appeared:

The two gyroscopes are placed under the car floor, one near each end, contained in strong iron cases, which also hold the shaft journals and spinning motors. Each case is itself journaled in trunnions on either side, so that it can rock forward and backward. The action of the gyroscopes appears to be about as follows: When the car tips sideward (tipping the gyroscopes sideward therefore), the gyroscopes become subject to a force tending to tilt them about the transverse axis. As they spin in opposite directions, one will tend to tilt forward, the other backward. A pair of geared sectors linked to the gyroscope cases causes them to tilt equal amounts, so that, viewed from above in the car, they will appear to be dipping toward each other or away from each other, but always equally.

Now, when the car tips to one side, the gyroscopes are subjected to a tilting moment, and as there is nothing to oppose a corresponding motion, they do tilt. But this, in turn, induces a pair of forces opposing the lateral tipping, i. e., a righting force. If the speed of tilting becomes rapid enough, it is able to generate a righting force sufficient to stop the car from further tipping and even return it to a vertical position. Briefly put, the tipping movement induces a tilting force (hence an acceleration), while the tilting movement induces an opposite tipping force (hence acceleration, which first checks the tipping movement and then starts to right the car). At all times, the induced rotational moment in one direction is proportional to existing rotational velocity in the other direction. Thus the sidewise tipping and forward tilting movements of the gyroscopes are out of phase with each other in their undisturbed condition, and just a quarter cycle out of phase. The natural consequence is that, a tip once started, the car will oscillate from side to side, just like a pendulum, or, better said, just as if the car were held by a strong spiral spring always tending to pull it back to central position.

Such a motion, if unmodified, would tend to continue, without decrease of the oscillations, except for the very slight friction of the car in tipping and of the gyroscopes tilting. This friction modifies the oscillation slightly, but does not necessarily tend to reduce the amplitude of oscillation. An excellent means to this end, however, is an arrangement for changing the phase-difference of tipping and tilting forces, so as to make the tilt lag less than 90° behind the tip during part of the cycle. This can be made to accelerate the righting action and check the tipping, evidently, so as to shorten the oscillation and soon bring about an almost quiet stable balance. The Scherl car uses this principle. The longitudinal tilting of the gyroscope cases moves the pilot valve of a hydraulic jack, whose piston increases the speed of tilting beyond that due to pure gyroscopic action; therefore a greater righting force is displayed than would appear under the free oscillating action.

This reinforcing mechanism of the righting action in turn requires to be controlled, of course, as to when it shall expend energy and when it shall absorb it, but the details of this as well as of the mechanism by which it is carried out were not made public. The absorption of the motion energy can obviously be made to occur in the hydraulic jack.

It may be mentioned that the gyroscope wheels in the present Scherl car weigh about 125 lbs. each, have a diameter of about 18 ins., and are said to run at a speed of 8,000 r. p. m. The claim is made that each gyroscope consumes about ¼ to ½ KW., as against 5 or 10 times as much when running in air. The oscillation of the tipping motion is very slow, corresponding, roughly, to a period of 20 or 30 sec. for a complete cycle, indicating a very close adjustment of righting force. The car is stated to weigh about 2½ tons; it measures about 18 ft. long, 4 ft. wide and 3½ ft. high over all. It is to be noted that on curves the car inclines inward, and in general automatically adjusts itself so that its center of gravity is over the support.

Mr. Scherl and his associates, who are seeking to exploit the system in the United States, are being assisted by Mr. Charles R. Flint, of 25 Broad St., New York City.

FIG. 2. THE SCHERL MONORAIL CAR ON A CURVE.

The Boston Engineering Dinner.

By CHARLES W. SHERMAN, M. Am. Soc. C. E.

One of the largest and most successful engineering meetings ever held in New England took place in Boston on the evening of Jan. 21, when about 450 engineers resident in Boston and vicinity gathered at the Hotel Somerset for a reception and dinner at which the Presidents of some of the principal engineering societies were among the guests of honor.

Plans for the dinner were made by a committee of arrangements headed by Prof. Ira N. Hollis, of Harvard, as Chairman, with Prof. Edward F. Miller and Mr. J. H. Libbey on behalf of the American Society of Mechanical Engineers, Messrs. H. F. Bryant and F. H. Fay on behalf of the Boston Society of Civil Engineers, and Messrs. N. J. Neall and J. F. Vaughan on behalf of the American Institute of Electrical Engineers.

After a reception lasting about an hour, the party sat down to dinner in the large ballroom of the Hotel Somerset. At the close of the dinner Prof. Hollis called the assembly to order and mentioned that the occasion was noteworthy in that among the guests were the Presidents of three of the national engineering societies and of the oldest engineering society in America, the Boston Society of Civil Engineers; moreover, there were in attendance the Presidents of sixteen engineering and scientific societies and of one institution for technical education.

He then called upon Mr. Charles B. Edwards, Chief Engineer of the Fore River Shipbuilding Co., who presented a short paper upon the engineering features of the battle-ship North Dakota, the holder of the world's record for speed, which has recently been built at the Fore River shops. Mr. Edwards said that his object was to illustrate some of the engineering problems which confront the naval officer on a modern battle-ship and particularly to show in what contracted space most of the work has to be done. He showed a large number of very interesting lantern slides. The ship is 518 ft. long, 85 ft. beam and displaces 20,000 tons at a depth of 26 ft. 10¾ ins. It contains 431 water-tight compartments, besides many other compartments which are not water-tight. One novel and extremely interesting installation is an ash-expeller operated by compressed air, by

which the ashes are forced through openings in the bottom of the ship at a point about 25 ft. below the water surface. Another important installation and one having a considerable influence on the high speed attained is the arrangement for burning oil fuel in addition to coal. A Schuette-Koerting ejector for oil is arranged to drive it in a spray over the top of the coal fire. There is an installation of 35,000 HP. of boilers in a room 45 × 25 ft. in plan and 25 ft. high. An unusual and interesting detail is a water circulation in an annular space around the steam pipes where they pass near the magazines, to prevent the transmission of heat to the magazines. Another interesting piece of apparatus is the torsion meter, installed upon the main shaft in the shaft tunnel, by means of which the horse power developed is indicated by the amount of twist in the shaft. This twist is actually about 1° when the full power of the ship is being developed. The electrical installation consists of four 300-KW. generator sets located in a space 40 × 22 ft.

Mr. George B. Francis, of the Boston Society of Civil Engineers, was called on as representing the oldest engineering society in America. Mr. Francis called particular attention to the fact that the present was the first joint meeting of the several engineering societies in Boston, and referred particularly in his remarks to the project for an engineers' home in Boston. For a number of years the Boston Society of Civil Engineers has been working towards a permanent headquarters with the desire of making it a home not only for that society but for other allied societies. At the last annual meeting the Committee on Quarters had been authorized to make an expenditure up to $125,000 for land and building, and the Board of Government of the society had been authorized to apply the permanent fund of nearly $25,000 to this purpose. Although the Committee had been soliciting subscriptions, the project was practically at a standstill. It did not appear practicable to finance the necessary expenditure. Bearing in mind that there are 5,000 engineers within a radius of 15 miles of Boston, Mr. Francis thought that a corporation or stock company organized to build a club-house in which the several societies should rent space and which should also furnish the usual facilities of a club to those who took out club membership, ought to be well supported, and he believed that such a project could be financed if the several societies would take blocks of stock in proportion to their means.

Prof. Hollis then introduced Mr. John A. Bensel, the newly elected President of the American Society of Civil Engineers. Mr. Bensel spoke briefly, expressing his sympathy with the idea of the local societies and clubs of engineers, more particularly for the social features.

Prof. Hollis then called upon President Stillwell of the American Institute of Electrical Engineers. Mr. Stillwell spoke especially upon the great advantages to be attained by co-operation between engineers engaged in different branches of engineering work and also in congratulation to the American Society of Mechanical Engineers in securing Mr. Westinghouse as its President for this year. Prof. Hollis then introduced President Sturgis of the Boston Society of Architects, who spoke briefly of the co-operation now existing between architects and engineers and expressed his belief that the Boston Society of Architects would be found ready to co-operate in the scheme for a local club house.

Hon. Charles Francis Adams, who has been associated for many years with Mr. Westinghouse as a director in his companies, then spoke briefly in appreciation of the great work accomplished by Mr. Westinghouse.

Mr. Westinghouse himself was then introduced and was heartily welcomed by the meeting. The desirability of co-operation and standardization was the theme of his remarks. He referred especially to the increasing extent to which corporations are coming under legislative regulation, and expressed his belief that this has resulted directly from unregulated competition and that the effects of such competition are notably apparent in electrical manufactures where each company has its own standards, often varying only in minor particulars, which results in an immense multiplicity of patterns and a great waste of money. After calling attention to the great loss which has resulted in the past from the variety of gages adopted by different railways and the trouble that resulted before a standard gage became universal. Mr. Westinghouse stated that a similar condition is likely to occur in the electrification of railroads unless immediate steps are taken to obtain uniformity. He felt that it should be just as possible to run an electric locomotive or car of one railroad over any other electrically equipped railroad as it now is to pull one freight car over any railroad in the country. He favored a Bureau of Standardization, to be established by joint action of the several engineering societies and to be supported by contributions of the manufacturers who would be so materially benefited by such standardization, and felt that if this were not done by the engineers and manufacturers themselves, it would lead in the near future to government regulation, which ought not to be necessary.

Prof. D. C. Jackson, Chairman of the local section of the American Institute of Electrical Engineers, then presented a motion to the effect that the Chairman of the meeting be authorized to request the governing bodies of the several local engineering and allied societies to appoint committees which should meet as a joint committee to consider the project for an Engineers' Club House suggested by Mr. Francis in his address. The motion was seconded by Mr. I. E. Moultrop on behalf of the Society of Mechanical Engineers and was unanimously carried. The meeting broke up at about 10.30 o'clock.

Annual Meeting of the American Society of Civil Engineers.

The annual meeting of the American Society of Civil Engineers passed off quietly and pleasantly as usual. Little professional work was accomplished except hearing progress reports of special technical committees. The meeting, held at the society's house in New York City (220 West 57th St.) Jan. 19 and 20, was well attended, though almost wholly from the Eastern and Ohio Valley States.

The single professional and business session was held on Wednesday morning, Jan. 19, adjourning about noon. The afternoon was occupied by a walk through the extensive new terminal station of the Pennsylvania R. R. at 32d St. and Seventh Avenue, by invitation of Mr. George Gibbs. In the evening the president, Mr. Onward Bates, received at the society's house. Thursday was devoted to a trip to the Ashokan Dam work of the new Catskill Reservoir for New York City's water-supply, the contractors, McArthur Bros. Co. and Winston & Co., being the obliging hosts. A smoker at the society house Thursday evening wound up the meeting.

OFFICERS.—The election of officers resulted as follows:

The new members of the nominating committee are: J. C. Meem (New York City); J. R. Worcester (Boston, Mass.); H. C. Allen (Syracuse, N. Y.); J. E. Greiner (Baltimore, Md.); Richard Montfort (Louisville, Ky.); Isham Randolph (Chicago, Ill.); R. H. Thompson (Seattle, Wash.).

Mr. John A. Bensel,* Commissioner, Board of Water Supply, New York City, was elected President of the society for the coming year.

Mr. J. T. Fanning (Minneapolis, Minn.) and Mr. Hunter McDonald (Nashville, Tenn.) were elected Vice-Presidents.

The new members of the Board of Directors are Messrs. Wm. E. Belknap and Horace Loomis (New York City); Mr. George A. Kimball (Boston, Mass.); Mr. Percival Roberts, Jr. (Philadelphia, Pa.); Mr. C. F. Loweth (Chicago, Ill.); and Mr. A. D. Foote (Grass Valley, Cal.).

Committee Reports.

COLUMN COMMITTEE.—The committee on columns submitted a progress report containing the plotted results of all available test records of wrought-iron and steel structural columns. To make them comparable even though the met of one test set was of lower strength than th of another, all reported ultimate strengths we reduced to a uniform basis by dividing by t ratio of ultimate tensile strength to a standa tensile strength of 60,000 lbs. per sq. in. Th modification was criticized by Mr. Thomas I Johnson (Pittsburg, Pa.), on the ground tha the ultimate tensile strength (considering th simple crushing strength proportional to it) play no part in column action within the range whe Euler's formula applies. However, as most o the tests were on material not far different fro mild steel, any error so introduced would not b very weighty. Moreover, the committee drew n conclusions from its diagrams, which are merel presented for record. It says that the result are so discordant that further tests on column are needed.

As to testing columns of very large cross-section the committee remarks:

> At the time your Committee was appointed, circumstances caused a demand for tests to destruction of compression members equal in size to the largest ever built for existing bridges. This demand was backed largely by both the popular and technical press, but careful consideration and study lead to the conviction that while such tests are desirable, the cost of making them is so great that there is no chance of obtaining a sufficient number to disclose any fundamental law. Elaborate series of tests on smaller columns, in which the details and processes of manufacture conform to commercial practice, would disclose the effects of the different variables and would determine the fundamental laws of the behavior of columns under stress. Such a series of tests, with the necessary investigations, should properly be made by the Federal Government.

The report was accepted as a report of progress, ordered printed, and the committee continued.

BITUMINOUS ROAD MATERIALS.—This committee, appointed only last May, has prepared a formulary of tests and methods of testing, and is now engaged in getting data from road officials, manufacturers of bituminous materials, etc., on the qualities and service results of different materials. The committee continues.

RAIL SECTIONS.—The committee reported that, drop-testing machines having been standardized, the test results of the different mills are becoming comparable, which in time will lead to useful results. Also, the systematized reports of rails in service initiated by the American Railway Engineering & Maintenance-of-Way Association should in time give usable information. In the meantime the committee has nothing to add to its report of a year ago.

STATUS OF METRIC SYSTEM.—This committee virtually reaffirmed its findings of October, 1908, which suggested that there exists too much ignorance of the metric system, and recommended that that report be sent to members of Congress and State legislators. Strong opposition to such a move developed quite promptly at the meeting, and the report was received without further action and the committee discharged.

CEMENT TESTS.—The cement committee report consisted chiefly of a minority report of Mr. Alfred Noble, who stated his belief that the committee has long ago finished its assigned work, and should therefore make a definitive report in place of the provisional or progress reports. The society later instructed the committee to submit a final report next year.

CONCRETE AND REINFORCED CONCRETE.—The committee asked to be continued. Its long report of a year ago has not yet been published in the "Transactions," but soon will be so published, with the discussion on it and the reply thereto.

ENGINEERING EDUCATION.—Mr. Desmond Fitzgerald reported progress for this committee. It expects to work first on Electrical Engineering courses, and seems to have good hopes of producing useful results toward simplifying and improving instruction courses.

*A portrait and biographical sketch of Mr. Bensel were contained in our last issue.

STREET CAR ACCIDENTS.—The Chicago City Ry. reports that a comparison of records for the period Nov. 24, 1906, to Jan. 31, 1908, with those for the period Nov. 24, 1907, to Jan. 31, 1909, shows a reduction of boarding and alighting and related accidents were reduced by 31.9%. During the latter period prepayment-type of cars were used on all trunk lines. In the earlier period such cars were used for two months on one line only.

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The single-rail gyroscope car has been brought prominently to public attention this month by the exhibition of a model car in Brooklyn. This car was brought to the United States by Mr. Richard Scherl, the son of a prominent German publisher. The car and its mechanism is described elsewhere in this issue, so far as any description of the mechanism is now permitted. We also show in this issue a view of a car lately exhibited by Mr. Louis Brennan in England, of much larger size than the miniature car which Mr. Scherl has built.

The exhibition of this Scherl car and the widely published accounts of its performance have given rise to much speculation as to the possible commercial applications of the gyroscope system. Both Brennan and Scherl claim that a great future lies before their invention in its application to railways of very high speed. They talk of propelling huge cars, much wider and longer than present-day Pullmans, at speeds of 100 to 150 miles per hour.

It has already been pointed out in these pages that the limitations to speed on present railways are fixed by quite other conditions than the safe limit of speed on a two-rail track; and that the traveling public is not even willing to pay fares high enough to make present highest speed trains profitable to the railways which operate them.

It may be worth while to suggest also some of the limitations that are likely to be encountered whenever it is attempted to balance by gyroscopes a car running at abnormally high speeds. Manifestly, the righting force of the gyroscopes must be made to exceed the tipping force on the car. Hence the weight of the gyroscopes must bear a certain proportion to the weight of the car. As the tipping force on the car increases very rapidly with its speed, the weight of the gyroscopes and the power absorbed by them must be proportioned to the speed of the car. It is still to be demonstrated that it would be feasible to balance a full-size railway car with gyroscopes at speeds of 100 miles an hour or more, and not have the gyroscopes so large that their use would be impracticable.

It has been suggested that the gyroscopic car may have a field of usefulness in the operation of very cheaply built single-rail lines; and something commercial may yet be worked out in this direction. As at present developed, however, the car is by far too complicated, expensive and impractical to be worth a moment's consideration for the pioneer railway lines, such as those used for lumbering, where only the crudest of tools are available for repairs. In fact, a view of the interior of the Scherl car recently exhibited in Brooklyn shows that it is crammed with a perfect nightmare of complicated apparatus.

In saying all this, however, we by no means overlook the fact that the gyroscopic system—the automatic balancing of a car over a single rail—is a marvelous scientific feat and the method by which it has been accomplished is a wonderful example of mechanical ingenuity. Nor do we by any means pretend to say that the invention is without commercial value. For display at expositions and amusement resorts it should have a large, legitimate and very profitable field.

Sanitary engineers ought to lose no time in taking a hand in shaping both public opinion and legislation regarding the creation of a national bureau of health. In our issue of Dec. 16, 1909, we barely called attention to a section of President Taft's message which dealt with this subject. As there is some prospect of early Congressional consideration of the creation of a national bureau of health it may be well to note just what President Taft said:

> For a very considerable period a movement has been gathering strength, especially among the members of the medical profession, in favor of a concentration of the instruments of the national government which have to do with the promotion of public health. In the nature of things, the medical department of the army and the medical department of the navy must be kept separate. But there seems to be no reason why all the other bureaus and offices in the general government which have to do with the public health or subjects akin thereto should not be united in a bureau, to be called the "Bureau of Public Health." This would necessitate the transfer of the Marine Hospital Service to such a bureau.
>
> I am aware that there is a wide field in respect to the public health committed to the states in which the federal government cannot exercise jurisdiction, but we have seen in the Agricultural Department the expansion into widest usefulness of a department giving attention to agriculture when that subject is plainly one over which the states properly exercise direct jurisdiction. The opportunities offered for useful research and the spread of useful information in regard to the cultivation of the soil and the breeding of stock and the solution of many of the intricate problems in progressive agriculture have demonstrated the wisdom of establishing that department.
>
> Similar reasons, of equal force, can be given for the establishment of a bureau of health that shall not only exercise the police jurisdiction of the federal government respecting quarantine, but which shall also afford an opportunity for investigation and research by competent experts into questions of health affecting the whole county, or important sections thereof, questions which, in the absence of federal governmental work, are not likely to be promptly solved.

As will be seen, there was nothing very definite in these remarks beyond an expression of the desirability of creating a bureau of public health and the assumption that in so doing various scattered governmental agencies now dealing with health matters, including the U. S. Public Health and Marine Hospital Service, would be united in both organization and in effort.

With what basis of fact we do not know, a press dispatch which apparently originated with the Committee of One Hundred on National Health circulates the report that President Taft will soon send a special message to Congress outlining the following definite plan for a bureau of health:

> The Department of Commerce and Labor to be renamed the Department of Commerce, Labor and Health.
>
> A new bureau of health to be created in this department, and to have transferred to it all the present functions of the Public Health and Marine Hospital Service, now in the Department of the Treasury; the pure food and drugs division of the Bureau of Chemistry, now in the Department of Agriculture, and the meat inspection service of the Bureau of Animal Industry, now in the Department of Agriculture.
>
> A commissioner of health to be put at the head of the new bureau.
>
> A bureau of children to be included within, or closely affiliated with, the new bureau.
>
> A new Assistant Secretary of the Department of Commerce, Labor and Health to be especially responsible for the conduct of the new health bureau, also the bureaus of labor, immigration and the census, which are said to be naturally interrelated.
>
> An advisory board of health to serve without pay as consultants for the new Assistant Secretary and his bureau chiefs, thus providing the best expert advice which the country affords in respect to health matters in their many aspects.

The proposed creation of the long-needed bureau of health is so important a matter and has such possible relationships to many engineers that it has seemed desirable to lay the proposition before our readers, even though it is not yet in very definite or authoritative shape. It would be well if the subject could be widely discussed before the inevitable bill is introduced in Congress, as it might be easier to shape legislation before than after that event.

We invite particular attention to the fact that neither in President Taft's message nor in the outline plan is there any definite recognition of the relation of engineers or engineering work to public health. A considerable part of the comparatively little public-health work thus far done by the federal government has been carried on or directed by engineers, and a large part of that awaiting to be done requires the guidance of the best engineering talent of the country. The engineering profession owes it to itself and to the country that it plays its proper part in shaping the legislation that will create a National Bureau of Health.

Every engineer with years of experience in professional work who has ever been "up against" a civil service examination for appointment or promotion will read with relish the paper by Maj. R. R. Raymond in this issue. Major Raymond does not overstate the difficulty of testing the abilities of an experienced engineer by an ordinary examination. It is fair to say, however, that in the wisest administration of the civil service laws, much greater weight is given to the record of past experience and the testimony as to character and reliability than to the results of any written examination. While the civil service laws are admittedly a crude method of selecting men, they have the great advantage of shutting out political considerations in the selection, and from that point of view have been of great public benefit.

The day-labor system as opposed to the contract method of making water-works and sewer extensions seems to be much more popular in the New England States than in other portions of the country. Some interesting figures on this point are given elsewhere in this issue in a very interesting paper by Mr. Harrison P. Eddy, M. Am. Soc. C. E., of Boston, on the relative cost of municipal work done by day labor and by contract. The paper relates primarily to the high cost and general inefficiency of day-labor in the Boston water and sewer departments, as shown by the recent investigations of the Boston Finance Commission. For comparative purposes, statistics relating to the day-labor and contract systems in other cities of the country were collected. Information secured regarding sewerage extensions in 73 cities showed that while outside of New England 94% of the cities tabulated made sewerage extensions by contract, within New England less than one-half of the cities under consideration employed that system. In Massachusetts only 1 of the 18 cities reporting relied upon the contract system, but taking the New England States as a whole, 67% of the cities did the work by contract.

For water-works extensions, the difference between New England and other states was not so great, except that in Massachusetts all of the 15 cities for which information was secured were making their extensions of water mains by day-labor. Mr. Eddy's paper does not attempt to explain why the day-labor system should be more popular in New England than elsewhere. It would be interesting to know the reason.

We presume that there are other groups of states where, taking cities large and small, the

day-labor system is much more in favor than the contract system. So far as can be judged from the information gathered by Mr. Eddy, the cost of constructing sewers by day-labor averages more than similar work done by contract throughout the Massachusetts cities considered. This particular comparison was not extended beyond Massachusetts.

In Boston, according to the paper mentioned in the foregoing paragraph, the average cost of constructing sewers by day-labor was even greater then the average cost by the contract system shown for other Massachusetts cities. Notable excesses of cost in day-labor as compared with contract work in Boston were also shown as regards the cleaning of catch basins and some other work. Mr. Eddy's paper may be profitably consulted for details.

We would call particular attention to the surprising increase in the cost of work brought about by occasional seemingly slight changes in rates of pay, hours of labor, and holiday allowances at full pay, particularly when these are accompanied by a decline in efficiency of the laborers. In the 20 years ending with 1907 wages in the Boston Water Department increased from $1.75 to $2.25 a day, or 28%. The nominal length of the working day during the same period was reduced from 10 to 8 hours; or, making further allowances for half holidays and full holidays, by 26⅔%. Reduced to terms of wages per hour for the time actually worked the average wage in 1888 was 17¼ cts. as against 31½ cts. in 1907. Thus, although the increase in nominal wage was only 28%, it resulted in an actual increase of 80% in the hourly wage. In other words, $1.80 was required in 1907 to pay for *time* which would have cost $1 in 1878. But meanwhile the amount of work done by these Boston laborers had fallen off 30%, so that $3.60 was required to pay for work which 20 years before would have cost $1.

The main cause of this decrease in efficiency and increase of cost of labor, Mr. Eddy states, has been the baneful influence of politics, which has been responsible for abnormal rates of pay for city, as compared with contract laborers, liberal all-day and half-day holiday allowances, employment of aged and physically incompetent men, the absence of discipline or lack of incentive, and inexperience on the part of those holding executive positions.

Inasmuch as the bad showing for the day-labor system in Boston reached its height during the administration of Mayor Fitzgerald, and had considerable part in bringing about the changes in the form of municipal government which we noted in our issue of Jan. 20, 1910, it will be highly interesting to see what results are obtained under the new system of government after Mayor Fitzgerald returns to office next month.

Of course some increase of pay and decrease in working hours between 1888 and 1907 was natural and justifiable. It would be interesting to know what a like investigation of contract work would show. It would be even more interesting to know the unit output of contract labor on city work now as compared with 20 years ago.

To what extent are the conclusions reached by Mr. Eddy and the Boston Finance Commission applicable to the increased cost of day-labor work in other cities? We cannot answer the question in definite terms, but in our next note we continue a discussion of some phases of the same general subject.

If one can judge from Chicago reports just in hand, quite as bad conditions prevail in the Sewer Department of that city as those we have just noted as pertaining to the Boston Water Department. These Chicago conditions have been brought to light by a report just made public by the Chicago Commission on City Expenditures, which was created by the government of that city last year. Prof. C. E. Merriam, of the University of Chicago, is Chairman of the commission. Among the various lines of investigation carried on by this commission has been one relating to the sewer department of the city. Mr. Benjamin F. Welton, of New York City, was put in engineering charge of this investigation, and with five assistants devoted some six weeks to the work. Much detailed information regarding the way in which the employees of the Chicago Sewer Department work and shirk when supposed to be in charge of cleaning catch basins is given in a recent report by Mr. Welton, from which we quote two paragraphs in the way of summary:

> The deductions to be drawn from this schedule are astounding. It is there shown by a succession of figures, whose uniformity attests the reliability of the observations, that the present average unit cost of cleaning catch-basins is 253% of what these very same gangs demonstrated they could make the average cost, and 340% of what several gangs showed should be the unit cost. In other words, the gangs themselves proved that their normal work showed a loss of efficiency of nearly 61% as compared with what they could do as a body and a loss of 70.6% as compared with what several individual gangs actually did. It is impossible to controvert the deductions thus drawn.
>
> It may be considered that a most conservative estimate of the existing pay-roll waste would not be less than 65% of the labor pay-roll expenditures. The records of the bureau of sewers show that over $350,000 was expended for the year ending Dec. 1, 1909. Sixty-five per cent. of the amount is approximately $228,000, which represents the annual waste in 1909.

Perhaps there is another side to the Chicago story, but the detailed report from which we have quoted gives internal evidence of being reliable.

If there is any consolation to the people of Boston and Chicago in knowing that the same general conditions summarized above prevail in still other cities, we may call attention to the remarkable increase in the cost of operating water-works pumping stations in Philadelphia, given in a letter from Mr. John C. Trautwine, formerly Chief of the Water Bureau of that city, published in our issue of Aug. 12, 1909; also to a pamphlet issued by the Municipal Affair Committee, of the Chamber of Commerce, Buffalo, N. Y. We will not now go into the astounding details of this pamphlet. Suffice it to say that although an investigation of the Buffalo Water Department was summarily terminated by the Commissioner of Public Works before its conclusion enough information had been secured to indicate that labor costs at the Buffalo pumping station were unduly high.

It is a gratifying sign of the times that investigations like those at Boston and Buffalo are being made in so many of our cities. They give promise of putting a decided check upon municipal inefficiency and extravagance. Some may think that such checks will be only temporary, but there are many indications that they will be permanent. Such charter reforms as have been introduced at Boston and as are under consideration for Buffalo, St. Louis and New York City will aid greatly in reducing municipal inefficiency, because they place responsibility more definitely and clearly than heretofore upon the several municipal officials. But no mere charter provisions can ever take the place of intelligent watchfulness and criticism on the part of the people as a whole, acting both as individuals and as civic organizations.

Stories from Cleveland, Ohio, to the effect that the new city administration, headed by Mayor Baehr, is likely to go back on the water-meter system sound unreasonable. The persistent extension of the use of water meters in Cleveland until practically the whole of the supply was sold by measure was accompanied by a marked decline in water consumption and waste. Beginning with a reported consumption of 169 gals. in 1901 the consumption fell to 100 gals. in 1908, the corresponding percentage of taps metered being 6.42 and 93.6, respectively (see Eng. News, Nov. 4, 1909).

The man to whom credit for this remarkable record is largely due, namely, Mr. Edward W. Bemis, lately Superintendent of Water-Works in Cleveland, has just gone to New York to take up the position of Deputy Commissioner of Water Supply, Gas and Electricity. He was selected for that position on the strength of his record at Cleveland as a most capable and efficient water-works administrator, and, as we hardly need say, no little part of his reputation in Cleveland was based on the tactful and skillful manner in which he induced not only the city officials but also the water consumers themselves to believe that the only fair and economical way of determining water charges is to base them on the actual consumption as shown by water meters. It seems probable that the reports of the reversal of meter policy at Cleveland were largely prompted by the desire of the local press to have something sensational to announce in the way of reversal of policies on the coming in of the administration which succeeded Mayor Johnson the first of the year. We really do not expect to see water meters at Cleveland "scrapped" by the score as they get in need of repair a possibility suggested by one of the newspapers of that city.

Civil Engineers in River and Harbor Work: An Old Story and a New Opportunity.

For more than a quarter of a century the position of the civilian engineers employed in river and harbor work has been a sore topic in the civil engineering profession.

The causes for dissatisfaction have often been set forth in these columns. To briefly refer to some of them, for the benefit of our younger readers, we may mention the fact that a civilian engineer, no matter how large his experience, how great his ability, or how heavy the responsibilities laid upon him, can never rise higher than the grade of Assistant Engineer. He is kept a subordinate all his life, in position, in pay, in public credit for the work which he does. A veteran of sixty, with the ripe experience due to a lifetime of engineering work, may be under the orders of a young lieutenant, with the vaguest knowledge concerning the engineering work of which he is nominally in charge.

Many a protest has been voiced against the system and at various times there has been agitation for the transfer of river and harbor works to the control of an organization of civil engineers. All these movements, however, have come to naught, partly because those who fostered them failed to appreciate the strong hold which the Corps of Engineers has upon public confidence.

The ablest men in public life appreciate the value to the country of an organization of engineers of high professional standing, holding a life tenure of office and secure from political interference.

The dangers to any organization of civilian engineers which might be created to take charge of river and harbor works in place of the Army engineers are well illustrated by the present happenings in the Reclamation Service, reviewed in our issue of Jan. 13.

Neither in the public interest or in the interests of the engineering profession as a whole is it regrettable, therefore, that past sporadic attempts to take river and harbor work out of control of the Army engineers have failed. It is greatly to be regretted, however, that nothing whatever has been done to better the position of civil engineers engaged in this work, and we believe this regret is shared by the best and ablest officers of the Corps of Engineers.

With the passage of time, a better understanding has been reached between the army engineers engaged in civil engineering work, and their colleagues in the civil engineering profession. We believe the ablest officers in the Corps of Engineers fully recognize and appreciate the unsatisfactory position of their highest grade civilian assistants with respect to pay, rank, tenure of office and opportunity for promotion. On the other hand, the civil engineering profession has come to appreciate the high grade of engineering ability and achievement with which many officers of the Corps of Engineers must be credited. They have come to understand, too, that the engineer officer is also unfairly treated by the Government, in that he has to carry a huge load of responsibility and perform a vast amount of work for very meager compensation.

It is of very great interest, therefore, to the profession as a whole to learn that at last something is likely to be done to give civil engineers

larger responsibility and larger credit for their work in connection with river and harbor improvements.

A bill is now pending in the House of Representatives (and, we understand, has excellent prospects of passage) which provides for an increase of 60 officers in the Corps of Engineers, the present authorized strength being 188 officers. This increase in the strength of the Corps is in accordance with the recommendation of General Marshall, Chief of Engineers, in his annual report for 1908—a recommendation which was repeated in his report for 1909.

The present bill (H. R. 27,372, 60th Congress, 2d session) originated in the River and Harbor Committee of the House of Representatives. It provides that the vacancies which are created by the bill in the grade of Second Lieutenant, "shall be filled, so far as practicable, by graduates of West Point selected as heretofore;" but vacancies not filled in this way may be filled by transferring officers from other departments of the army, or *by the appointment of civilian engineers.*

Section 3 of the bill provides that a civilian engineer to be eligible for examination and appointment as a Second Lieutenant must be an unmarried United States citizen between 21 and 29 years of age, must be a graduate from an approved engineering school, and must be eligible for examination under civil service rules as a junior engineer for service under the Corps of Engineers. The selection of civilians for such appointment would be made by a competitive examination.

While this section opens a door by which graduates of other schools than West Point can enter the Corps of Engineers, it does nothing for the experienced civilian engineers of mature years now in the service. These are provided for by Section 4 of the bill, which reads as follows:

> That whenever it shall be necessary, in order to properly execute works of river and harbor improvement, the Chief of Engineers is authorized to detail for duty in charge of river and harbor districts, or as members of boards of engineers, any assistant engineers in the employ of the Engineer Bureau of the War Department.

It is worth while to understand the situation which has at last forced open the door through which civilian engineers can be promoted to the positions of responsibility in charge of river and harbor work that ought to have been theirs a quarter-century ago. This situation, briefly stated, is that the experienced officers in the Corps of Engineers are now far too few in number to carry the responsibilities which are placed upon them.

According to the last report of the Chief of Engineers, there are only 48 officers of all grades on duty under exclusive control of the Chief of Engineers, whereas there were 71 in 1897. In other words, about two-thirds as many men have now to carry the responsibility for two or three times the amount of work which was being carried on thirteen years ago. Congress has three times increased the authorized strength of the Corps of Engineers since 1897. At that time there were 109 officers in the Corps, and there are now 188; but the increase has been more than absorbed by the increase in the military duties devolving upon the Corps.

The actual situation is admirably set forth in the paper by Major Raymond, of the Corps of Engineers, which is printed elsewhere in this issue. That paper was written to discuss the uses and abuses of the graduate school for the instruction of engineer officers; but it reveals a situation which is full of interest to those who would see our river and harbor work carried on by competent and experienced men. Major Raymond says:

> The burdens of the Corps of Engineers are steadily increasing, while the time available for the preliminary training of young officers is as steadily decreasing. Only two years are now available for this training, and during these years the students are assigned to all kinds of duties which interfere with their school work or interrupt it entirely.

Again he says:

> We have too few officers to assign the young ones for several years to work already properly administered by older men. Under present conditions our captains are themselves inexperienced, and but little older than their lieutenants. They are not old enough to undertake the training of young officers.

The facts set forth by Major Raymond explain present aggravated conditions in the engineer service. Because there are not enough old and experienced officers to fill all the posts, important work has to be placed in charge of very young officers, quite inexperienced in the work for which they have to carry the responsibility. Is it strange that the civil engineering profession protests against conditions which cause a youthful captain or lieutenant, of 27 or 28, to be placed in authority over a civilian engineer who has grown gray in the service, and who knows vastly more concerning the technical matters committed to his charge than does the young officer over him?

From the point of view of the public welfare, however, the case is even more serious. The officers of the Corps of Engineers are at present in a situation demanding the greatest good judgment, diplomatic wisdom, and wise discretion. The craze for waterway improvements which has swept the country during the past four or five years has brought forward a great number of foolish, unwise and unprofitable schemes for waterway development. We must look to the Corps of Engineers to have the backbone and good judgment to present all such projects to the public in their true light. Such work is work for men of mature years, experience and standing. It is not work for young men in their twenties, no matter how brilliant their minds or how great their future promise.

In view of these conditions at the present time, an additional section has been drafted for inclusion in the bill from which we have quoted above, and this section reads as follows:

> That neither officers nor civilian engineers shall be detailed in charge of river and harbor districts until they have had at least eight years experience as assistants on that class of work and until they have attained the age of 35 years. That in future all boards of engineers considering or reporting on river and harbor works shall have detailed as members at least one-third of their number civilian assistant engineers in the manner provided above.

We believe this section will meet the approval of all engineers, military or civil, who have given fair and unprejudiced study to the subject. While there may be an occasional brilliant young man who is competent to have full charge of a river and harbor district when under the age of 35, such men are the rare exception, and there will be no serious harm done by incorporating such a restriction in the law. On the other hand, the great advantage will be secured of ensuring that the civil engineering work in connection with navigation improvements is placed in the hands of men of experience.

We referred at the outset to the agitation which has gone on in past years to secure for the United States assistant engineers something of the recognition to which they are entitled by long and faithful service. At the present time, it seems likely that this recognition is at last to be given them. There is, however, no certainty as to the progress of the bill in Congress, and the point we particularly wish to make clear to our readers is that the opportune time for the profession to put forth efforts in its own behalf is the present.

We understand that thus far not a voice has been raised at Washington by an engineer or an engineering organization to urge this recognition of the engineering profession. Surely this is an opportunity that ought not to go unheeded. Those of our readers who are familiar with the situation of the United States assistant engineers, and of the need that their professional work should be placed upon a proper plane for the credit and dignity of the profession, should see to it that appeals are forwarded to Congress. Far better than individual effort would be action by engineering organizations. If resolutions were adopted by a dozen leading engineering organizations, urging that the civil engineering work of river and harbor improvement be placed upon a better basis, as provided for by the pending bill, we believe such resolutions would have great weight with the congressional committee having the matter in charge. Unless some such action is taken the committee must necessarily remain somewhat uninformed as to the feeling of the profession in the matter.

LETTERS TO THE EDITOR.

Continuity in Reinforced-Concrete Beams.

Sir: For the benefit of the profession the writer submits the following references, which seem absolutely to controvert the statements made by Mr. Spaulding in his letter published in your issue of Jan. 13, 1910, p. 48:

As to the effect upon the stiffness of concrete beams of the tensile strength of the concrete see

University of Illinois Engineering Experiment Station, Bulletin No. 4. Tests of Reinforced-Concrete Beams, pp. 74-81.

University of Illinois Engineering Experiment Station, Bulletin No. 12. Tests of Reinforced-Concrete T-Beams, pp. 32-34.

Einfluss der Armatur und der Risse im Beton auf die Tragsicherheit, by E. Probst, pp. 87-92.

Der Eisenbetonbau, by E. Morsch. (English Translation, Concrete-Steel Construction, pp. 192-193.)

"Stresses in Reinforced-Concrete Beams, . . ." paper by Professor Lanza before American Society of Mechanical Engineers, read Nov. 9, 1909.

Mitteilungen der Eidgen. Materialprüfungsanstalt am Schweiz. Polytechnikum in Zürich. 13 Heft. Versuche Für die Schweiz. Kommission des Armierten Beton. Untersuchung des Einflusses der Druckspannungen in Eisenbetonbalken und der Breite bei Druckplatten, pp. 12-16.

The only experiments known to the writer, aside from his own, concerning effective flange widths are to be found on pp. 17 to 50 of the last above-mentioned publication.

Furthermore, the method employed by the writer for determining the stiffness ratio is based upon that contained in the Leitsätze of the Verband Deutscher Architekten-und Ingenieur Vereine and the Deutscher Beton Verein in the year 1904, and in the Regulations of the Royal Prussian Ministry of Public Works, for the construction of reinforced-concrete buildings, May 24, 1907. Finally, the writer's tests of parts of buildings in actual use further confirm the criticism made by him of Mr. Spaulding's paper.

The method used by the writer in his first communication for computing the moments was that employed by Mr. Spaulding as interpreted by the writer. It is very possible that some numerical error might have entered through misunderstanding or misapplication, but this does not affect the general principle involved.

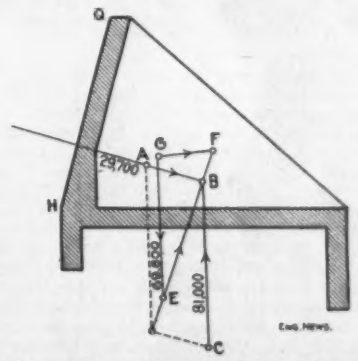
Very truly yours,

E. P. Goodrich.

2 Rector St., New York City, Jan. 15, 1910.

The Design of the Dansville Concrete Dam.

Sir: Your issue of Jan. 13, 1910, p. 52, gives an account of the failure of a concrete dam at Dansville, N. Y. There is nothing at all surprising about this failure. To me it would have been a surprising thing if it had stood the pressure of water behind it for any considerable period of time. I have shown in a sketch herewith the general shape of the dam and the forces acting on a bay. The net resultant of these forces is G F. This force does not strike the middle third of the base. It does not strike the base at all. It does not even strike the ground. It has a rising inflection, so to speak, and would tend to give the dam a down-



Approximate Stress Diagram of Dam at Dansville, N. Y., Under Water Level at Top of Dam.

(The dimensioned section of the dam is shown in Engineering News, Jan. 13, 1910, p. 52.)

stream and upward course pressure on the flash boards was ignored in figuring these stresses, but the assumption of such additional pressure would show diminished stability.

The forces acting on the dam are A B; the water pressure on the sloping face, Q H; B C, the water pressure beneath the slab; and G E, the weight of the dam.

It may be contended that the force B C due to pressure under the slab was not intended by the designer to act. But designer's good intentions are not always respected by water and materials of construction, and designer's assurances that structures are acting as they were intended to act are not always convincing.

The force B C, 81,000 lbs. in my sketch, is due to

water pressure under the slab. Your article states that witnesses say that water was squirting up out of weep holes in this slab. But assurance is given by the engineer that the gravel below the dam was not wet. Both statements may be correct, as the gravel below the dam may have been porous enough to carry off this leakage in a sub-stream. Porosity in the gravel would increase pressure under the slab.

There are some very pertinent questions that could be asked regarding this dam and dams of like construction.

Why was this slab used in the design? The pressure on the soil is not so great as to need all of this spread. If it was used to prevent leakage of water that passed the toe wall, would this not mean pressure upward on this slab? Would not pressure of water beneath this slab greatly impair its stability, especially if it was not designed with stability enough to resist such pressure?

Why was the heel wall made relatively so much deeper than the toe wall? Is this not to confine the water under the slab? Would it not have been better to add this entire wall to the toe wall and omit entirely the heel wall? The heel wall was not made a girder, though the slab was reinforced as a load suspended upward from it. The slab could have been reinforced from buttress to buttress, and this would have given the same soil pressure, if soil pressure were the thing the slab was designed to give.

Why were weep holes made in the slab? Does this not indicate that it was anticipated that water would get under the slab? Weep holes would relieve the pressure in the immediate vicinity of the several holes. They would prevent the water, in spots, from accumulating and reaching the pressure due to its head, but unless the water flows freely, it will exert a pressure. Nothing but a sieve-like construction would be free from pressure, and such construction would defeat the manifest purpose of the slab.

In just the proportion that the base slab is useful in retaining the flow of water it is a menace to the stability of the dam by reason of the pressure of the water retained.

This type of dam condemns itself, when made in proportions approximating this example; because, on the face of it, elaborate preparations are made to prevent the escape of water that works its way beneath the dam, and a little graphic computation will demonstrate that the dam is rendered unstable by the pressure of this water in seeking an outlet.

Yours very truly,

Edward Godfrey, M. Am. Soc. C. E.

Monongahela Bank Building, Jan. 17, 1910.

The Design of the Walls for the Gatun Locks at Panama.

Sir: In a former letter to Engineering News, published Dec. 2, 1909, certain criticisms were made of the design of the Panama Canal locks.

Col. Hodges, replying thereto, took issue with the writer on some points raised, hence it seems necessary to again refer to this subject in order to reply to his statements.

There is certainly one important point on which Col. Hodges and the writer seem to agree, namely: "either a flat floor or an invert, if made strong enough would undoubtedly be efficient as a bottom for the upper lock at Gatun." The writer admits that he should not be taken literally regarding his former statement as to the solution of the arch. Certainly the stresses in an arch can not be solved unless the loading is known, neither can the stresses in a flat floor be solved unless the loading is known and even then so many uncertainties enter the Gatun problem as to make its solution unsatisfactory. Assumptions as to loading must be predicated on known facts and most probable conditions and of course would be the same for either type of floor.

The solution outlined in the "Canal Record" of July 14, develops the fact that the integrity of the floor is dependent upon the soundness and tensile strength of the rock to which the floor is anchored. The rock is known to be of a soft and porous nature and should the upper ledge let go the underlying rock, the stresses developed will be sufficient to rupture a beam or flat arch of this nature. As to the relative cost of the two designs the writer makes the following estimate based on unit prices used in the 1908 estimate, using for invert design an arch 16 ft. thick with an inner radius of 156 ft. The solution of this arch shows the stresses to be well within the safe working limits of massive concrete.

For 450 lin. ft. of flooring for each upper lock the cost of invert is estimated to be.....	$520,000
The cost of flat floor is estimated to be.....	463,000
Difference in favor of flat floor.....	$57,000

If this were the whole story the difference is too small to warrant the adoption of an uncertain design such as a flat floor. This does not however represent a saving as will be shown later.

In suggesting that the invert be carried throughout the entire flight of Gatun locks the writer based his remarks on (1) the generally reported condition of the foundation and especially upon Major Harding's report in the "Report of the Commission" for 1908, p. 124 and Plates 55 to 61 inclusive. (2) The cost necessary to channel and excavate the trenches for the subsidiary culverts. This cost will probably equal the cost of excavating the entire amount to the grade of the bottom of the trenches. The report above referred to states that each of the locks rest in part upon the conglomerate and "that ground water is present under considerable pressure in some of the conglomerate." These pressures may be increased when the lake is filled. Of course, if further developments show the character of rock to be so good that there is no possibility of danger from an upward pressure, it would be unwise to carry the invert the full length of the lock flight.

It is admitted that the curtain wall may reduce a general flow of water from the south provided the material underlying the soft sandstone is not water-bearing. But as it is thought the "water approaches the lock site from the southeast" (Report of 1908, p. 125) and "the test-pits indicated an underground flow from the eastward" (Col. Hodges in Engineering News Dec. 2) and the elevation of ground water at lower gates is only about 5 ft. below that at upper gates (See holes 676 and 679 plate 57 Report 1908) and these elevations are likely to be increased when the lake is filled, it does not seem probable that the curtain wall will materially reduce the pressure acting under the lock floor. It would at least be unwise to depend on it.

The writer sees no force in the suggestion that "an actual material removal of particles of the sandstone might take place" if the curtain wall is not used. The material is hard enough to require the use of powder in excavating the test-pits and the velocity of ground water in it can not be great; and moreover as the sandstone is confined between either a more solid rock or concrete it does not seem reasonable that a noticeable breaking down of the particles will occur. Either dry or wet sand makes a very good foundation when efficiently confined and is being repeatedly used as such in lock construction by successful lock engineers who have no fear of failure of said foundations.

The cut-off wall suggested by the writer to be placed at the head of upper locks was intended primarily to intercept any flow of water that might find its way along the back of the lock walls and need only be carried to a good connection with the undisturbed rock at the sides of the excavation. While such a wall is not an essential feature of the lock design, its use would reduce the seepage into the back fill and lower the point of saturation.

As the Commission's curtain wall is built as a precautionary measure to reduce pressure and otherwise protect the flat floor and its anchoring, its cost should properly be charged to such a floor. No such construction is necessary for an invert design. The cost of the curtain wall is estimated to be at least $180,000.

Col. Hodges gives two guiding reasons for placing the lock floors below the sills, namely: "to allow the water to circulate more freely when it or the vessel shall be in motion, and to prevent possible injury from some small sunken obstruction which may drift into the lock or may be dropped from a passing boat. He also states that the upper sills are protected by the bottom of Culebra Cut, which is 3 ft. higher. A reference to the plans will show that the depth of water in channel below the locks is at least 2 ft. less than depth on lower sills of the upper lock. At Sault Ste. Marie the floor of the lock limits the draft of vessels running between Duluth and Buffalo, a distance of 1,000 miles. Naturally boats making this run are loaded till they will just drag over the floor. This lock does an enormous business operating constantly throughout the season. Many of the boats are of larger tonnage than the average boat that will use the Panama Canal locks and much more nearly fill the locks. Moreover the largest vessels afloat can not load to within 6 ft. of the lower sill of the Panama locks and if they could, there are only two or three ports of the world that could accommodate them with present or projected harbors. This condition may change in the distant future so that an occasional boat may load to depth of water on miter sill provided canal has been deepened.

However, if it is thought wise to set the floors below the sills, the extra cost of such construction should be charged to the flat floor for the invert naturally accomplishes the purpose. If the invert were used, a short section should be made flat on top to protect the sills. The distance the floors are placed below the sills will require a corresponding amount of extra excavation throughout the full width of the lock pit and the same extra thickness of concrete at the base of all the lock walls. The extra cost for these items for all the locks is estimated to be about $500,000. In addition to this the stresses in the lock walls are increased about 5%, which requires an additional amount of concrete or reduces the stability of the walls. The additional expense of lowering the floor along the stretch anchored is placed at $32,000. This with the cost of the curtain walls makes $212,000 that should be added to the cost of the flat floor, making a total of $675,000, which is 30% in excess of $520,000 which the invert would cost.

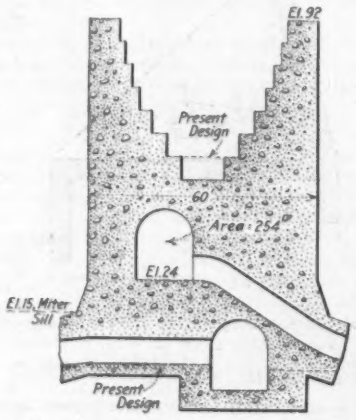
In his former letter, the writer seemingly does not make himself clearly understood regarding the velocity of water entering the 550-ft. lock. It has been argued that the side culverts only will be used in filling the small locks. In that case there are only 35 openings available in the 550-ft. lock, while there are 105 in the 1,000-ft. lock using both culverts. Assuming the same rate of filling, it is evident there must be a greatly increased velocity at entrance.

The writer had not forgotten that the middle wall is much narrower at the gate recesses than in the lock chambers and had taken this into account in stating that two culverts could be built in this wall. Figs. 1 and 2 show a possible location of these culverts and a proposed modification of the center wall. An analysis of the forces in the walls shows that no excessive stresses are produced, even in the 43-ft. wall. Moreover it is probable that owing to the monolithic nature of the concrete a considerable per cent. of the water pressure against the 43-ft. wall is carried to the 60-ft. wall whose moment of stability is much greater. This per cent. can be increased by proper bonding and construction. While these stresses are not excessive it must be remembered too that the loading assumed (one lock empty and one full) is exceptional and not the constant working load. The culverts shown are of the same cross sectional area as the one adopted for the middle wall by the Commission. The elevation of the lower culvert is not fixed in the sketches, its location being somewhat dependent upon the nature of the foundations and the upward pressure of the ground water under the lock floors.

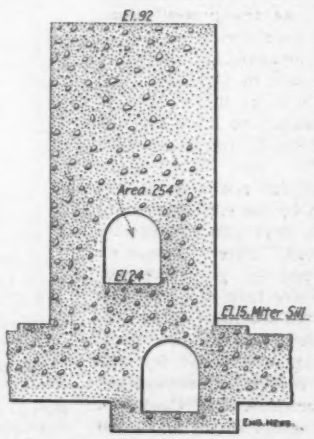
Possibly there may be a theoretical movement of the boats that would not require the use of both culverts but boats have a habit of coming in a way not in accordance with theory. It must be remembered that with the system as designed there are 20 extra valves and more moving parts in each flight of locks and when any one of them is out of commission the whole system is out of commission and the time of filling and emptying the 1,000-ft. lock is increased about 40%. The feature of saving water by emptying one lock into its twin can be accomplished by a single cross culvert connecting the two main culverts.

It is believed that the advantage and necessity of having two culverts in the middle wall is of enough importance to justify a reasonable expenditure of money to secure them. It is not likely, however, that there will be any material additional cost.

Summarizing his former letter the writer criticized: the design of a flat floor in upper lock anchored to the rock foundation with its attendant evil features of a curtain wall intended to intercept the underground flow



Section through Chamber Wall. Fig. 1.



Section through Gate Recesses. Fig. 2.

SECTIONS OF PROPOSED CENTER WALL FOR GATUN LOCKS AT PANAMA, CONTAINING TWO CULVERTS.

of water, and a system of sumps with tell-tale pipes for determining the upward pressure of underground water; objectionable location of curtain wall; form of culverts; excessive width of side walls requiring nearly 15% additional concrete and an excess of excavation; placing of lock floor 15 ins. below top of lower miter sill; middle walls with only one culvert with resultant subsidiary valves. He then suggested the following changes: inverted arch floor; cut-off wall across head of lock to reduce seepage and improve drainage of back-fill so that side walls can be narrowed to a width of 42 to 45 ft.; rectangular culverts with circular top in place of circular culverts; placing of lock floor to form protection to miter sills; two culverts in middle wall keeping width of wall at 60 ft.

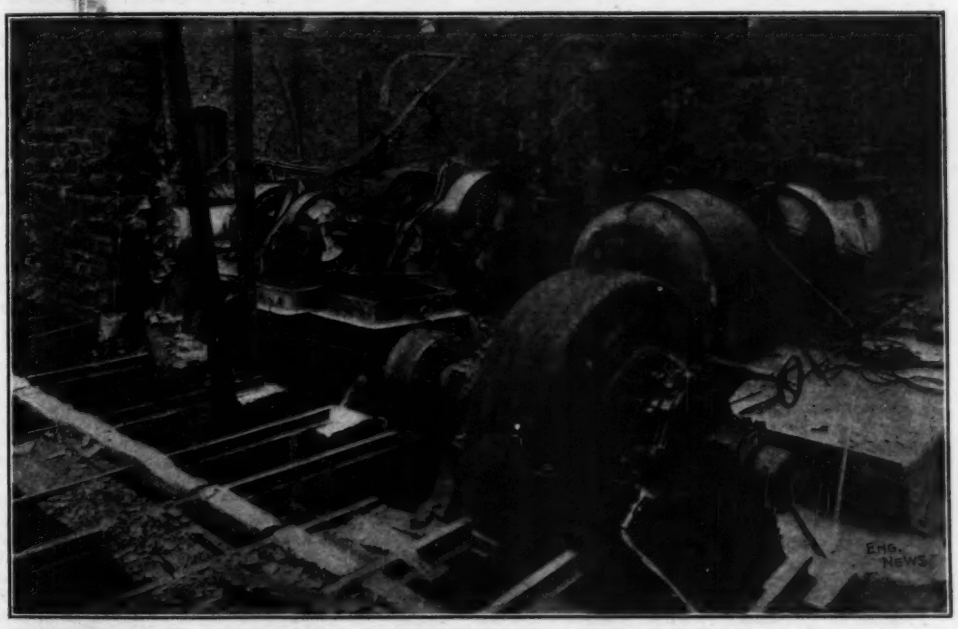
Col. Hodges' reply stated his opinion as to the efficiency of the flat floor, the sumps and tell-tales, and the curtain wall and defended the approved designs in all the following particulars: location of curtain wall; one culvert in middle wall; subsidiary valves in lateral culverts; circular culverts; and placing of floor below level of miter sills.

M. G. Barnes, M. Am. Soc. C. E.

Albany, N. Y., Dec. 29, 1909.

Two Steam Turbines which Passed through a Fire with Slight Injury

Two steam turbines withstood a severe test of exposure to intense heat during a recent fire, at the Trinidad plant of the Southern Colorado Power and Railway Co., in which two simple reciprocating engines and the electrical machinery attached to them were damaged beyond repair. An idea of the effect of the heat can be had from



INTERIOR OF THE TRINIDAD PLANT, SOUTHERN COLORADO POWER AND RAILWAY CO., AFTER FIRE.

the view taken after the fire. Although the power-house had rough stone walls, the roof and floor were of wood with light steel trusses for the roof supports, and old T-rails for the floors. These pine floors were oil-soaked, causing a rapid spreading of the flames and adding greatly to the heat generated. The fire originated in the failure of some second-hand electrical equipments under heavy load, and the burn-out ignited inflammable material surrounding the apparatus. In three minutes after the start it was impossible to get inside the engine room.

At the time the fire was observed, load was being transferred from the 500-KW. to the 1,000-KW. steam-turbine unit, and the automatic safety stops were tripped immediately after the floor took fire. It is considered probable these machines were spinning during the greater part of the fire, but no effects of rubbing were reported, due to the cylinder warping from the unequal heat exposure.

As was to be expected, some exterior parts of both units were damaged. The cylinder lagging was badly warped, and the governor-valve gearing, valve-piston rings, and all springs on both machines were ruined. The relay plungers were fused to the bushings, and the brass railings on the top platforms were partly melted.

Although the generator frames were discolored from the heat, the actual loss was very small. The brush holders were practically destroyed, and the insulation burned off one of the leads on the 1,000-KW. unit. This is the extent to which the generators suffered. This experience is said to have convinced the makers of the ability of the insulation used in such units to withstand high temperatures.

The 500-KW. unit was repaired in ten days after the fire and the 1,000-KW. unit in 12 days. This included the delay in getting parts from the factory. The actual cost of repairing both units was about $2,000, including painting. This was about 5% of the first cost.

A Westinghouse-Leblanc condenser, connected to the 1,000-KW. unit also was not affected, except for damage to the gaskets on the small piping and to the pump motor. Yet a surface condenser, attached to the 500-KW. machine, had the shell cracked at the middle, the failure extending practically around the entire periphery. The turbines were made by the Westinghouse Machine Co., East Pittsburg, Pa., to whom we are indebted for this information.

A LARGE BRITISH WATER POWER PLANT was recently completed. It is a 30,000-HP. plant at Kinlochleven, Argyllshire, built for the British Aluminum Co. The gross head utilized is 940 ft. The water of the river Leven is impounded by a concrete dam 86 ft. high at the maximum, and about 3,000 ft. long. From here it is carried on the hydraulic grade by a concrete open conduit, 8 x 8 ft., 3½ mi. long, to a headbay built at the point where the steep drop to the power-house begins. The penstock comprises six lines of welded steel pipe, 39 ins. in diameter, 6,200 ft. long. This formidable pipeline first descends a hillside on 27% gradient, then crosses the level valley floor of a tributary to the Leven, and then descends the side of the Leven valley on a flat gradient to the power-house. The machinery comprises nine 3,000-HP. turbine-generator sets, with room for three more of the same size. At 10% overload capacity, the present equipment totals 30,000 HP., while the future capacity is 40,000 HP. The hydraulic part of the plant was designed for a flow of 415 cu. ft. per sec. in the open channel, at about 7 ft. per sec. velocity. The penstock was designed so that with one pipe out of commission the full power could be generated without exceeding 8½ ft. per sec. velocity. The right-of-way was graded to a width sufficient to accommodate two more pipes, or eight in all. The pipes are in 20-ft. lengths, one end left plain as spigot, the other expanded to form a deep socket whose outer end is flared. A steel flange ring fits around the flared part of the socket, and bolts to a corresponding ring slipped over the spigot and having a toe that presses against the hemp packing in the socket. Thos. Meik & Sons, of London, were engineers for the work.

Relative Cost of Municipal Work Done by Day-Labor and Contract, in Boston, Mass.*

By HARRISON P. EDDY,† M. Am. Soc. C. E.

Among the various lines of investigation carried out by the late Boston Finance Commission were several which threw considerable light upon the relative efficiency of the contract and day-labor systems and some of the causes of the inefficiency of the day-labor forces of the city of Boston.

An effort was made to ascertain as nearly as possible the actual facts in all cases, and to reduce the conditions to figures, thus eliminating opinions. The results of these investigations are, therefore, interesting and important, as showing the results of conditions surrounding city departments, and not as exploiting theories of ideal conditions which are rarely found in any city.

While most of the data refer to the city of Boston, it is believed that the lessons drawn from them are typical, and that similar results would be obtained from like investigations in many other cities.

Relative Prevalence of Contract and Day-Labor Systems Outside of Boston.

In order to ascertain the general municipal practice throughout the country in building water-works and sewerage systems, a postal-card inquiry was sent to all cities in Massachusetts, and to all cities in the country exceeding 30,000 in population, as shown by the Census Bureau in 1905. The questions were so worded as to apply only to ordinary extensions, and it is probable that in some cases work upon new systems may have been done by contract, while ordinary extensions were made by day-labor. Postals were sent to 154 cities, and replies relating to sewerage systems were received from 73 cities, and relating to water-works extensions from 58 cities.

Of the 73 cities making replies to the inquiries relating to sewerage systems 52, or 71%, were found to be doing this class of work wholly by contract. Of the cities located outside of New England 94% were found to be doing their work by contract, while but 67% of the cities in New England outside of Massachusetts were using this system, and in Massachusetts only 6%. The prevalence of the day-labor system in Massachusetts is very strikingly shown by these figures, which, it should be noted, are based upon replies from all of the 18 cities to which inquiries were sent. Putting it in another way, of the 18 cities in Massachusetts one was doing its sewer work wholly by contract, while 17 were doing similar work wholly by day-labor.

Replies to the inquiries relating to water-works extensions were received from 58 cities, and of this number 33% were found to be doing the work wholly by contract. Outside of New England 48% of the cities have adopted the contract system, while in Massachusetts of the 15 cities making reply to the inquiries all were found to be doing the work by day labor. The results of the inquiries relating to water-pipe extensions are very similar to those relating to sewer construction, and both show very clearly that the day-labor system is very widely adopted in Massachusetts, and much more prevalent in that state and in New England than throughout the remainder of the country.

Comparative Cost of Day-Labor and Contract Sewer Work in Various Cities.

A comparison was made of the cost of building sewers in cities where work was known to be done by day-labor with that in other cities where similar work is done by contract. These comparisons were confined to New England cities, and very largely to cities in Massachusetts.

To make this investigation less difficult and reduce the element of uncertainty as much as possible, the inquiry was confined to small pipe sewers from 8 to 12 ins. in diameter. Since most sewers of this class built in Boston have been constructed under contracts (largely "gift" or non-competitive contracts), the number available for comparison was smaller than was desired. As the difficulty in selecting work done under comparable conditions was fully realized, and as such selection could only be made by engineers familiar with local conditions, an assistant was sent from place to place to interview the local engineers, who always very kindly, and at times at considerable inconvenience to themselves, carefully considered the conditions surrounding a large number of pieces of work, and advised which should be selected for use in this comparison. The number of sewers selected in each city was small, but included all which could be classed as being built under conditions enabling fair comparison within the last few years. While it is realized that this study may be criticised as being based upon fragmentary and possibly insufficient data, it is presented as comprising the best data which could be obtained after a long and earnest effort to get at the truth. Unfortunately, in no city except Boston was this class of work found to be done both by day-labor and by contract, so that compar-

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†Read before Sec. 1 of the American Association for the Advancement of Science, Dec. 28, 1909.

isons between the two methods in the same city were impossible, with the single exception noted.

These investigations were made in 17 cities, 13 of which do their work by day-labor (including Boston, which does part of its work by day-labor and part by contract), and 5 (including Boston) which do the work by contract. The average cost (Table I) of building 12-in. sewers in 12 cities was found to be $2.17 per lin. ft., while in the city of Boston similar work appeared to cost $5.20 per lin. ft. Like work done by contract was found to cost on the average $1.82 in 4 cities, while in Boston it cost $2.35. Outside of Boston the average cost of labor and teaming in cities where the work was done by day-labor was $1.34 per lin. ft, as compared with 0.75 per lin. ft. in the four cities doing work by contract. In Boston, the work done by day-labor cost $3.50 per lin. ft., and that done by contract was $1.05 per ft., or 70% less.

In tables [not reprinted here] the cost of labor upon small sewers built by day-labor and by contract has been tabulated after being reduced to a uniform basis of wages of $0.315 per hour, the rate paid in Boston. Reduced to this basis, it appears that the cost of sewers built by day-labor (not including Boston) averaged for labor $1.79 per lin. ft., while in the cities doing work by contract (excluding Boston) the average cost of labor was $1.17. Treating in the same manner similar work done in Boston by day-labor and by contract, it is found that the labor cost was $3.50 and $1.32 per lin. ft., respectively. It, therefore, appears that had the rate of wages been uniform in all cities the labor cost of the work done by contract would have been 35% less than the labor cost of that done by day-labor, not including Boston in this comparison. Comparing the work done by both methods in the city of Boston, it appears that had the work done by day-labor been done by advertised contract the reduction in the cost of labor would have amounted to over 62%.

Comparative Cost of Sewers Built by Day-Labor and by Contract in Boston.

The costs of eight pairs of sewers, so selected as to be as nearly comparable with each other as possible, have been compiled in Table II. In each pair one sewer was built by day-labor, and one by contract. The pairs were selected by engineers employed by the city, who had direct personal knowledge of the conditions under which the work was done. After reducing the costs to equal terms as to size, depth and wages, it appears that in the case most favorable to day-labor the cost of the sewer built by direct labor was nearly double that of the one built by contract, while in the case of the pair most favorable to the contract system the one built by day-labor cost nearly four times as much as the one built by contract.

The Relative Cost of Cleaning Catch-Basins by Day-Labor and by Contract.

A study was made of the cost of cleaning catch-basins by day-labor and by contract. This study included the cost of cleaning nearly 9,000 catch-basins at a total expense of over $54,000. The cost of doing this work by day-labor averaged $6.39 per catch-basin, or $2.47 per cu. yd. of refuse removed from the basins, while that done by contract cost $4.15 per basin, or $1.46 per cu. yd.

Relative Cost of Manufacturing Valves by the Boston Water Department Shops and Purchasing the Same by Contract.

For many years the Boston Water Department has maintained a shop for repairs and the manufacture of a portion of the gate valves, hydrants and smaller fittings required for construction purposes. The business of the shop amounted in 1907 to $44,000. A comparison of the cost of manufacturing valves with the cost of the same if purchased by contract showed an increased cost under the day-labor system varying from 6% to 60%, as follows:

3-in.	valves	30%
4- "	"	60
6- "	"	53⅓
8- "	"	32½
10- "	"	47
12- "	"	24½
16- "	"	10
13- "	"	12
24- "	"	6

Under stress of these investigations and simply by the automatic stimulus of them, the cost of labor upon these gates was reduced about 35%.

Decrease in Efficiency of Labor Force in Boston Water Department.

The city engineer of Boston has for many years kept a careful record of the cost of trench work done in connection with the laying of certain classes of water pipe. The results of this tabulation are shown graphically by Fig. 1. The solid line shows the cost per foot for labor upon trench work. In this compilation the engineers have carefully excluded all work done under unusual conditions, so that the figures are as nearly as possible comparable from year to year. The broken line indicates the same costs reduced to a uniform basis of wages and hours of labor. It will be noticed that during the first two years the cost per foot was a little over $0.20, and during 1905 it was about $0.88. The cost, after reducing to a uniform basis of 10 hrs. per day and a wage of $2, was of course increased during the periods when the employees were receiving $1.75 per day, and decreased during the latter years when the hours of labor and wages were less than 60 hrs. per week, and more than $2 per day, respectively, and shows accurately the relative efficiency of the labor from year to year.

These data have been used in producing an efficiency curve (Fig. 2) by averaging the unit costs for the first 15 years during which period there was no marked tendency either up or down (1880 to 1895), and assuming that that average represents an efficiency of 100%. Stating the premises in another way, the average number of feet of pipe laid for $1 during those 15 years represents an efficiency of 100%. The variation from year to year is shown by the dotted line and the averaging for 15 years (100%) as well as the curve showing the general tendency from 1895 to 1907 by the heavy line. Beginning in 1895, it will be noticed that the line of efficiency fell gradually until it reached 50% in 1907.

From all the information available, it appears that this study of cost and efficiency is based upon very full and reliable data, and that comparison from year to year can be fairly made, although of course a better and safer result may be obtained by averaging several years, and making a comparison on that basis. In whatever manner the comparisons are made, it is apparent that the efficiency of the day-labor force has dropped about 50% in the last 12 years. In other words, in 1907 the average employee did only one-half as much work in a given length of time as he did in 1895. In this connection it should be remembered that there are many causes for this decline in efficiency, some of which are entirely independent of the personal effort of the laborers, and for which they should not be held in any way responsible. It is also true that this decline is not necessarily an inherent result of the operation of the day-labor system, and that system has been in use in other cities for many years, where a decline of such proportions is not apparent.

It is also interesting to note that the cost of work (Fig. 1) was reduced by including with the work done by day-labor also that done by contract during the years 1904-7.

TABLE I.—AVERAGE TOTAL COST PER FOOT OF COMPARABLE 12-IN. SEWERS LAID 10 FT. DEEP IN VARIOUS CITIES.

City or Town.	Prevailing diameter of sewer, ins.	Actual total cost per ft.	Total cost of equivalent 12-in. sewer without allowance for difference in wages.	Subdivision of cost into: Labor and teaming only.	Materials and sundries.	Engineering.
Built by Day-Labor.						
Brockton	8	$1.73	$1.96	$1.20	$0.68	$0.08
Cambridge	8	2.35	2.58	1.70	0.81	0.07
Everett	8	2.09	2.32	1.55	0.68	0.09
Fitchburg	12	1.80	1.80*	0.95	0.77	0.08*
Haverhill	10	1.68	1.80*	0.90	0.82	0.08*
Lawrence	10	2.38	2.50*	1.80	0.62	0.08*
Lowell	10	2.30	3.42	2.35	0.98	0.09
Medford	8	1.80	2.03	1.05	0.92	0.06
New Bedford	10	1.88	2.00	1.30	0.67	0.03
Newton	8	1.65	1.88	1.05	0.73	0.10
Quincy	8	1.54	1.77	1.00	0.68	0.09
Worcester	10	2.00	2.00‡	1.20	0.70	0.10
Average	..	....	$2.17	$1.34	$0.75	$0.08
Boston	12	$5.20‡	$5.20	$3.50†	$1.55	$0.15
Built by Contract.						
Brookline	8	$1.73	$1.95	$0.80	$0.80	$0.25*
Portland	10	1.50	1.62	0.65	0.81	0.16*
Providence	12	1.68	1.68	0.65	0.83	0.20*
Somerville	8	1.75	2.05	0.90	0.91	0.24*
Average	..	....	$1.82	$0.75	$0.86	$0.21
Boston	12	$2.35	$2.35	$1.05+	$0.90	$0.40

*Engineering estimated $0.08 per ft.
‡Exclusive of office and shop charges as in other cities.
†Owing to the fact that this figure is based upon a comparatively small number of examples, it should be used with caution.
‡Not including proportion of undivided construction cost which amounts to about 5% of total construction cost.
*Engineering and inspection.
+Advertised contracts only.

That *no correction has been applied on account of difference in wages.*

The *day-labor* cost shown in Column 4, includes labor on manholes, whereas the *contract labor* does not include this, but does include loss on sheeting, which substantially offsets it.

Efficiency of Labor and Rate of Wages Paid.

An effort was made to ascertain the prevailing rate of wages paid by contractors in the vicinity of Boston for work similar to that performed by the city Water and Sewer Departments. Data were obtained from 35 different contractors.

The minimum rate of wages paid in this vicinity appears to be 15 cts. per hr., and the maximum did not exceed in any case 30 cts. per hr. Comparatively few laborers are employed at rates of pay exceeding 25 cts. per hr., while large numbers are paid as low as 20 cts. In general, it may be stated that English-speaking laborers are paid more than others, and further that the rate of 30 cts. applies quite generally to building laborers or to laborers who possess rather more than average skill. In no case was it found that laborers were paid for legal holidays, and only in two instances were Saturday afternoons allowed. None of the contractors gave Saturday afternoons off with continued pay, and in no case were laborers paid in event of absence from work on account of injuries received.

The contractors furnishing data do not "carry" their employees through the winter unless they have work which must be done. In other words, they do not "find" work for their laborers during the winter season as do the city departments, and consequently they do not give continuous employment.

Inquiries were sent to sewer departments of all the cities in Massachusetts and several of the larger cities of the other New England states, to ascertain the length of day and the rate of wages in force upon municipal sewer work in the city departments. The data thus collected is compiled in Table III. Several of the cities included in this inquiry performed their construction work by contract, so that the figures given in those cases apply only to the maintenance forces. From this data it appears that the prevailing length of day is 8 hrs., although in some cases a 9-hr. day is required. Excluding Boston, the nominal rate of pay varies from 17 to 28.7 cts. per hr., while the prevailing rate of pay may fairly be said to not exceed 25 cts. per hr. In about one-third of the cities the laborers are permitted to have half-holidays on Saturday, although in about one-half of these cases the half-holidays are restricted to the summer months. In several of the cities where half-holidays are granted the length of day is so arranged that the laborers work 48 hours during the week. In

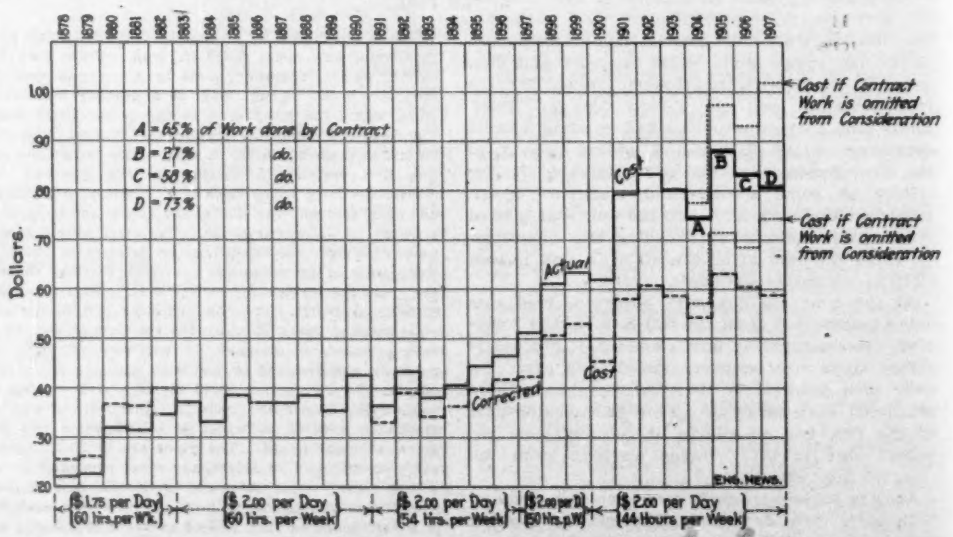

FIG. 1. COST OF TRENCH WORK FOR WATER MAINS UP TO 12 INS. DIAMETER IN BOSTON, MASS., 1878 TO 1907.

(Full line shows actual cost; broken line shows cost reduced to uniform basis of $2 per day and a 10-hour day.)

TABLE II.—COMPARISON OF COSTS OF CERTAIN PIPE SEWERS LAID IN BOSTON BY DAY-LABOR AND BY CONTRACT.

Location.	How done.	Date.	Length, ft.	Size, ins.	Aver. cut, ft.	No. M.H.	Rock, cu. yd.	Cost per lin. ft.	Cost per ft. on equal terms.	Ratio of day labor to contr. costs.
Allston pl., Brighton.....	Day	Jan. 27 to March 2, 1905.	$304.03	12	10.5	2	(?)	$5.59	$5.59	2.4
Corey Rd., Brighton.....	Contract.	Aug. 23 to Sept. 17, 1907.	400.00	10	12.3	2	4.81	2.42	2.34	
Willow St., W. Roxbury...	Day	Aug. 18 to Nov. 9, 1905.	1,126.57	12	11.6	5	(150)	7.74	7.74	3.2
Maple St.....	Contract.	Jan. 10 to May 25, 1906.	1,100.00	12	10.7	6	218	2.25	2.45	
Dunboy St.....	Day	Sept. 16 to Oct. 1, 1904.	175.65	12	7.0	1	no	5.13	5.13	3.7
Hardwick St.....	Contract.	May 2-18, 1904.	756.4	12	7.2	4	18.89	1.41	1.38	
Revere St.....	Day	July 28 to Aug. 16.	132.32	12	14.4	2	....	13.98	13.98	2.1
Tennyson St.....	Contract	Oct. 26 to Nov. 10, 1906.	221.07	12	10.6	..	1.66	5.05	6.48	
Charles St.....	Day	June 11 to 13, 1904.	230.6	12	10.5	..	....	5.96	5.96	rush job 2.0
Hale St.....	Contract.	June 8 to July 3, 1903.	269.3	12	11.7	2	....	3.35	2.98	
Charter St.....	Day	June 30 to July 20, 1905.	191.57	15 (12)	10.6	..	....	7.79	7.79	1.48
Hanover St.....	Contract.	Oct. 28 to Nov. 30, 1906.	333.33	15 (18)	9.3	..	....	4.68	5.26	
South St.....	Day	Jan. 30 to May 2, 1903.	318.1	18	16.6	..	....	21.39	21.39	2.78
Fayette St.....	Contract.	Sept. 16 to Dec. 5, 1906.	384.7	18	13.1	..	....	6.29	7.68	
North St.....	Day	Nov. 4 to Dec. 17, 1903.	141.51	30 × 36 brick	612.6	..	....	45.44	45.44	2.74
Cooper St.....	Contract.	Aug. 5 to Oct. 10, 1907.	210.1	36 × 36 brick	12.6	..	....	16.54	16.54	

These pieces of work were picked out by the District engineers as substantially comparable.

Lineal foot costs are based on total cost of labor, teaming, explosives and supplies excluding engineering and administration, office and yard department, cost of materials, i.e., pipe, brick, cement, manhole covers and steps. In each comparison the lineal foot costs are reduced to terms of like diameter of sewers and like average depth of trench.

five cities granting Saturday half-holidays laborers are paid in full for Saturdays during the summer months (varying from two to six months).

From a comparison of the wages paid by contractors and by municipalities it is evident that city laborers are paid considerably more than laborers employed by contractors and that they work fewer hours per week. It is difficult to determine the relation existing between high wages and the efficiency of the employees. It is doubtless true, however, that higher wages are paid by municipalities very largely because of political influence.

In this connection it is very interesting to note the increase in wages paid for common labor in the city of Boston from 1878 to 1907. From 1878 to 1883 the wages paid were $1.75, and the length of day was 10 hrs. In 1883 the rate of wages was increased to $2 per day. In 1891 the length of day was reduced to 9 hrs., and in 1897 Saturday half-holidays were allowed *with pay* In 1900 the 8-hr. day was granted, together with the continuance of the Saturday half-holiday, and in 1907 with the same hours the rate of wages was increased to $2.25. It therefore appears that between 1878 and 1907 the rate of wages had increased from $1.75 to $2.25 per day, or 28%, and the hours of work had been reduced 26⅔%. The result of reducing the length of day and increasing the rate of pay is made more apparent by comparing the rate of compensation per hour as in Table IV.

Nominal Time Worked and Wages Paid Laborers by the City of Boston.

Period.	Hours per week.	Nominal rate of wages—Per day.	Per hr.
1878-1883.....	60	$1.75	17½ cents.
1883-1891.....	60	2.00	20 "
1891-1897.....	54	2.00	22⅛ "
1897-1900.....	50	2.00	24 "
1900-1907.....	44	2.00	27⅓ "
1907-date.....	44	2.25	*31⅛ "

*Allowance made for legal holidays for which full pay is allowed.

From this tabulation it appears that the hourly wage, making due allowance for the Saturday afternoons and holidays, has increased from 17.5 to 31.5 cts., an increase of 80% in the cost to the city for the work done, assuming equal efficiency. In this connection it should be noted that while the cost of labor to the city has increased 80% per hr., the increase in daily wages received by employees has amounted to but 28%.

It is further important to note that while the cost per hour to the city for labor has increased 80%, the efficiency of labor, as already shown, has fallen 50%. In other words, a dollar's worth of time in 1878 would to-day cost the city $1.80, but the efficiency having dropped 50% the city is obliged to pay $3.60 for the amount of work done in 1878 for $1, an increase of 360%.

It would not seem unreasonable to expect that some relation may exist between the rate of wages paid and the efficiency of labor, or in other words that enough more work would be done per hour under the higher wages and shorter hours so that at least as many feet of sewer would be laid for one dollar as in cases where lower rates of wages prevailed. The following tabulation shows the number of feet of sewer laid for one dollar when the wages are reduced to a uniform basis of calculation. The percentage of efficiency is calculated on the assumption that the Brockton labor was 100% efficient:

	Rate of wages actually paid. Per day.	Per hr.	Number of feet of sewer laid for $1 figured on uniform basis.	Per cent. efficiency, assuming 100% eff. in the one case when wages = $0.281.
Brockton	2.25	0.281	0.746	100%
Seven cities...	2.00	0.254	0.529	70.9
Worcester.....	1.85	0.231	0.613	82.1
Three cities...	1.75	0.219	0.694	93.0
Boston	2.25	0.315	0.286	38.3

While it may not be fair to draw the conclusion from these figures that labor is less efficient *because* of higher wages, it does seem to follow that higher compensation does not *assure* greater efficiency. The greatest efficiency was apparently obtained in the case of the city of Brockton where the nominal wage is $2.25 per day, although in Boston, where the same nominal wage is

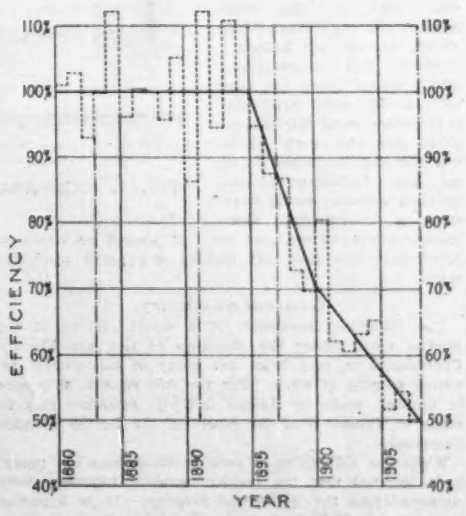

Fig. 2. Efficiency of Labor in Boston Water Department, 1880 to 1907.

(The average efficiency for the 15 years, 1880 to 1904, was taken as 100%. Data was reduced to a uniform basis of wages and hours.)

paid and holidays granted in sufficient number to increase the rate per hour over 12%, the lowest efficiency was indicated. Averaging the results obtained in cities paying the same rate of wages, there appears to be a gradual decrease in efficiency as the rate of pay increases.

Holidays and Sick-Leave.

The effect of political influence is shown very clearly in the granting of holidays and sick-leave with pay to city laborers. The cost of holidays, half-holidays and sick-leave is an item the magnitude of which is not very generally appreciated. The Boston Water Department has very carefully compiled statistics relating to this source of expense. During 1906 the distribution division expended upon pay-rolls about $450,000, and the amount charged to holidays, half-holidays and sick-leave amounted to over $34,000, or 7.7% of the total pay-roll. The lowest percentage for any month was 5.3, and the highest was a little over 10% of the respective pay-rolls. During the first eight months of 1907 the money paid for holidays and sick-leave amounted to 8.3% of the total cost of labor. During this entire period of 20 months, the pay-rolls amounted to $752,000, and nearly $60,000, or 7.95% of the amount of the pay-rolls, was expended for holidays and sick-leave.

Age of Laborers.

Perhaps one of the most frequent criticisms by the public of day-labor departments is that the men employed are too old for the work they are required to do, and consequently that the amount of work done per man per day is ridiculously small. This appears to be the universal opinion, and unfortunately in many cases there is much to substantiate it. An investigation of the Boston Sewer Department furnishes considerable interesting information pertinent to this criticism. Of the employees of this department, the investigation included 715 connected with the labor service. The ages of the various employees, as well as their terms of service, were obtained from the State Civil Service records, and are classified in Tables IV. and V.

Considering these tables as of date of their preparations (1907), it is found that of the 65 men who were from 60 to 64 years of age, four had seen less than five years of service in the department; six had seen from 5 to 9 years' service; 20 between 10 and 14 years; 28 between 15 and 19 years; *and only* 7 *had served the department* 20 *years or more.* Of the 21 men from 65 to 69 years of age, two had worked less than five years; two others from 5 to 9 years; six from 10 to 15 years; five from 15 to 20 years; *and only six had been employed in the department* 20 *years or more.* Of the 9 men from 70 to 74 years old, two had labored from 10 to 14 years; four from 15 to 19 years, and *three only for* 20 *years or more.* There was one man over 75 years of age and he had labored 40 *years or more for the department.* Sixty-one (9%) of the 715 employees had worked 20 years or more. *There were* 97 *employees over* 60 *years of age, but only* 18 *of them* (18.5%) *had served the department for* 20 *years or more.*

Many will maintain, and with much justice, that men who have worked for the city for 20 years are entitled to consideration, but from the following statement of facts it appears that few are in need of charity. Of the 56 men who were over 40 years of age, and who had served 20 years, 9 were employed as watchmen, which work they could perfectly well do. Four were filling positions for which they were not suited, and three were filling absolutely useless positions, leaving 40 men out of 56 men who were performing laborious work. Stating this matter in a different way, it appears that out of 715 laborers there were only 16 who were 40 years of age or older who had served the city 20 years, and who were incapacitated for laborious work, and of these 16, nine were able to serve as watchmen. This condition leads to doubt as to the necessity for establishing a pension system for the labor force unless such system is to be established for the benefit of employees who have passed their years of usefulness in the service of other employers, and who have late in life received, probably through political influence, positions upon city work.

The policy of appointing men upon the labor service after they have passed their years of usefulness in the service of other employers had turned the department into a semi-charitable institution, where aged and infirm men were employed when they should have been the charges of relatives or of the public, and not placed upon the city pay-rolls at wages higher than first-class able-bodied laborers at similar work could command from other employers.

Experiment to Test the Efficiency of the Day-Labor Force.

All of the work upon which the previous comparisons and comments as to efficiency have been made was work done prior to the investigations which were consequently studies of records of work already completed. It was not, therefore, possible to know accurately the conditions under which the work was done. At the request of the mayor of Boston a test was made at the Chestnut Hill stone-crusher (a municipal plant which

TABLE III.—STATISTICS CONCERNING THE DAY-LABOR FORCE OF THE SEWER DEPARTMENTS OF VARIOUS CITIES.

City.	Number of laborers.	Length of day, in hrs.	Rate of pay per hr. Nominal.	Rate of pay per hr. Actual.	Saturday half-holidays allowed.	Pay for Saturday half-holidays.	Allowance for sick leave.
Lynn, Mass.	101	8	28⅛ cts.	28.7 cts.	May-Oct.	Yes	None‡
Haverhill, Mass.	...	9	28⅛ "	28.7 "	June-Sept.	Yes	" §
Fall River, Mass.	178	8¼	28⅛ "	28⅛ "	Yes	....†	"
Brockton, Mass.	70-100	8	28⅛ "	28⅛ "	No	....	" ‖
*New Haven, Conn.	...	9	27½ "	27½ "	No	....	" ‡
Cambridge, Mass.	21	8	25 "	26.1 "	May-Nov.	Yes	"
Springfield, Mass.	78-153	8	25 "	25½ "	Work 7 hrs.	Yes	" §
Chicopee, Mass.	...	8	25 "	25 "	No	....	" ‡
Holyoke, Mass.	...	8	25 "	25 "	Yes	....	" ‡
Lawrence, Mass.	114	8	25 "	25 "	Yes	....†	Half pay
Lowell, Mass.	...	8	25 "	25 "	In summer	....†	None
Marlboro, Mass.	...	8	25 "	25 "	No	....	"
Medford, Mass.	...	8	25 "	25 "	No	....	"
New Bedford, Mass.	86	8⅛	25 "	25 "	Yes	....†	" ‡
Newport, R. I.	...	8	25 "	25 "	No	....	"
Waltham, Mass.	...	8	25 "	25 "	No	....	" §
Newburyport, Mass.	5	8	25 "	25 "	No	....	"
Quincy, Mass.	...	8	23½ "	23½ "	No	....	" ‖
Worcester, Mass.	168	8	23⅛ "	23⅛ "	No	....	"
*Hartford, Conn.	...	9	22½ "	22½ "	No	....	"
Waterbury, Conn.	14	9	22½ "	22½ "	No	....	" §
Bangor, Maine.	4	9	22½ "	22½ "	No	....	"
Fitchburg, Mass.	...	8	22 "	22 "	No	....	Full pay‡
*Albany, N. Y.	...	8	21⅞ "	21⅞ "	No	....	None
North Adams, Mass.	28	8	21⅞ "	21⅞ "	No	....	" §
Newton, Mass.	75	8	21⅞ "	21⅞ "	No	....	"
Concord, N. H.	...	9	19½ "	19½ "	No	....	" ‡
*Portland, Maine.	...	9	19½ "	19½ "	No	....	" ‖
Hudson, N. Y.	...	8	18¾ "	18¾ "	No	....	Full pay
*Providence, R. I.	84	9	17 "	17.2 "	July-Aug.	Yes	None§
New London, Conn.	40	9	16⅔ "	16⅔ "	No	....	" §
*Somerville, Mass.	8-15	8	... "	... "	In summer	....	"
Boston, Mass.	2,000	8	30⅝ "	31½ "	Yes	Yes	Full pay‡

*Maintenance only; construction by contract.
†Work 48 hrs. per week but time divided so that Saturday is a half-holiday.
‡In case of injury, submitted to a committee.
§Full pay if injured on work.
‖Unless injured on work.
‡Full pay may be allowed not to exceed 60 days when approved by Mayor.

TABLE IV.—LABOR EMPLOYED IN BOSTON SEWER DEPARTMENT CLASSIFIED ACCORDING TO AGE.

Present age.	No. of men.	Per cent. of force.	No of men abv. ages designated.	Per cent. of force above ages designated.	Term of service, years. Avg.	Max.	Min.
Below 20	1	0.1	-	0	2	2	2
20-24	5	0.7	20-714	20-99.9	3.2	9	0
25-29	19	2.7	25-709	25-99.2	3.8	12	0
30-34	53	7.4	30-690	30-96.5	6.1	15	0
35-39	101	14.1	35-637	35-89.1	7.5	18	0
40-44	127	17.7	40-536	40-75.0	9.9	22	0
45-49	136	19.1	45-409	45-57.3	13.0	28	0
50-54	95	13.3	50-273	50-38.2	12.7	32	0
55-59	81	11.3	55-178	55-24.9	5.3	33	2
60-64	65	9.1	60-97	60-13.6	14.8	35	1
65-69	21	2.9	65-32	65- 4.5	13.6	21	1
70-74	9	1.3	70-11	70- 1.6	17.3	23	11
75-79	2	0.3	75-2	75- 0.3	32.0	40	24

Note: Investigation made in 1907.

TABLE V.—CLASSIFICATION OF LABOR BY TERM OF SERVICE AND AGE, BOSTON SEWER DEPARTMENT.

Present age.	Years of service 0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	Total
19	1	..	..	..	..	..	..	..	..	1
20-24	3	2	..	..	..	..	..	..	..	5
25-29	10	8	1	..	..	..	..	..	..	19
30-34	19	25	8	1	..	..	..	..	..	53
35-39	28	28	38	7	..	..	..	..	..	101
40-44	26	26	41	30	4	..	..	..	..	127
45-49	8	20	52	43	9	4	..	..	..	136
50-54	7	21	26	31	7	2	1	..	..	95
55-59	2	11	18	34	11	2	3	..	..	81
60-64	4	6	20	28	3	..	2	2	..	65
65-69	2	2	6	5	6	..	..	..	..	21
70-74	0	0	2	4	3	..	..	..	..	9
75-79	0	0	0	0	1	..	..	..	1	2
Total..	110	149	212	183	44	8	6	2	1	715

had been shut down) to determine whether or not it was possible for the day-labor force to produce broken stone at a cost fairly comparable with that of similar stone purchased by contract. The test covered a period of three months during the summer of 1908, and was under the observation of a disinterested engineer, who kept accurate record of what was done, but who did not in any way supervise or direct the forces. The work consisted of stripping and quarrying the stone, hauling it to the crusher and breaking it.

The test lasted a sufficient length of time to demonstrate with accuracy the cost of producing broken stone by day-labor under the existing conditions. The force consisted of men apparently as skillful and competent as could be selected from the employees of the Street Department, and certainly gave evidence of being reasonably skillful and competent. So far as could be observed, the foreman in charge was given an absolutely free hand to organize his force as he deemed best, and to adopt such methods of handling the work as he might desire. With slight and unimportant exceptions, tools and supplies were promptly furnished, so that there is no reason to think that the output could have been increased by the improvement of conditions depending upon the cooperation of the superior officers of the department. The net result of this test appears to be that broken stone was produced at a cost of $1.075 per ton. These figures make no allowance for the cost of clerical service at the office or for the cost of administration, which items are estimated at 5 cts. per ton; and no allowance was made for the cost of the quarry. Depreciation of plant and the rental of tools were included in the cost of producing the stone.

The quarry and crusher selected were the most favorable of any of the eight which the city had worked in the past, and in 1895 produced broken stone more cheaply than any other of the city crushers. It is only fair to add that during the second and third periods of the tests, the time being divided into three periods, there was a marked increase in the efficiency of the force. A fair estimate of the cost of the output of broken stone during these latter periods was 95 cts. to $1 per ton, no allowance being made for administration nor for owning and maintaining of the quarry. For comparison, an instance was found where the operations of a large broken-stone company was started with certain temporary machinery, which was rented to a contractor, who crushed stone for a period of four or five months. The physical conditions were fairly comparable with those at the Chestnut Hill plant. The crusher was similar, the output was smaller, and rental was paid for the machinery. The cost to the contractor for this work was 45 cts. per ton, not including interest and depreciation, which would bring the cost up to 50 cts. per ton. It therefore seems fair to conclude that the work which cost the city practically $1.12 per ton, including administration expense, would have cost a competent contractor about 50 cts. per ton. It should be borne in mind that this does not include any profit upon the work.

General Summary.

The foregoing discussion of a small portion of the studies made under the direction of the late Finance Commission is very brief, for many of the studies required months of work. For the full reports, fifty-nine in number, made by Metcalf & Eddy, reference may be made to Volume 3 of the report of the Boston Finance Commission.

While the difficulties of such investigations are many, it is believed that the results recorded represent very conservatively the conditions existing. It is apparent that municipal work done by day-labor is in general, under conditions of to-day, much more expensive than similar work done under the same conditions by contract. It is also apparent that the labor force in city departments, where work is done by the day-labor system, is very inefficient as compared with similar forces employed by contractors and has, during the last ten or fifteen years, decreased greatly in efficiency at least in the city of Boston.

There are many causes of the excessive cost of day-labor work and of the inefficiency of the day-labor forces, all of which may be grouped under the one great evil—the entrance of politics into municipal business. These causes include abnormal rates of pay, the granting of holidays and half-holidays, the employment of aged and physically incompetent laborers, absence of discipline, a lack of incentive, and the inexperience of those in executive positions. It would further appear that the number of men growing old in the service of the city, who were at the time of their original employment young and vigorous, is not a material cause of inefficiency. On the other hand, the employment of men in city departments who have passed their years of usefulness in the service of other parties, has a demoralizing effect upon the labor forces and has undoubtedly been the cause of much of the inefficiency noted in municipal day-labor forces.

A Unique Type of Reinforced-Concrete Construction.*

By THEODORE L. CONDRON,† M. Am. Soc. C. E.

With the introduction of reinforced-concrete as a building material, the familiar forms of floor construction were very naturally reproduced in this material. The gradual development of this reinforced-concrete construction may be outlined in seven types: (1) slabs carried by steel joists and girders; (2) slabs and joists carried by steel girders; (3) long-span slabs carried by steel girders; (4) slabs, joists and girders; (5) long-span slabs and girders; (6) slabs, without beams or girders; (7) paneled slabs, without beams or girders.

In the summer of 1907, the writer's partner, Mr. F. F. Sinks, designed and made complete sketches for a new type of reinforced-concrete floor construction, eliminating the usual girders and beams.‡ After very carefully analyzing the stresses in this design, we decided to make tests to demonstrate the correctness of our analysis. We had models made to one-eighth size of a portion of the first floor of the Manufacturers' Furniture Exchange Building, reproducing 2¼ panels of the floor construction and columns. We also had another model made of the same proportions and with the same column spacing but following the girderless slab design referred to. The surface area of these models was approximately 20 sq. ft. each.

A simple apparatus was arranged for testing by hydrostatic pressure, the models being supported on heavy steel I-beams and a testing platform covering the up-

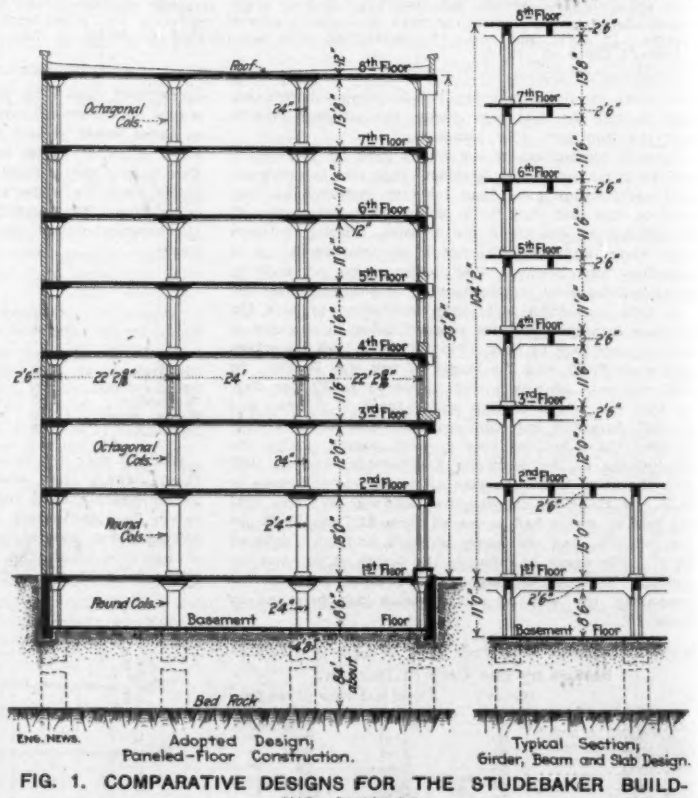

FIG. 1. COMPARATIVE DESIGNS FOR THE STUDEBAKER BUILDING, CHICAGO.

*Abstract of a paper read before the Western Society of Engineers, Chicago, and printed in the December number of the Society's "Journal."

†Consulting Engineer, 1214 Monadnock Block, Chicago.

‡Mr. Sinks has applied for letters patent, covering the construction described.

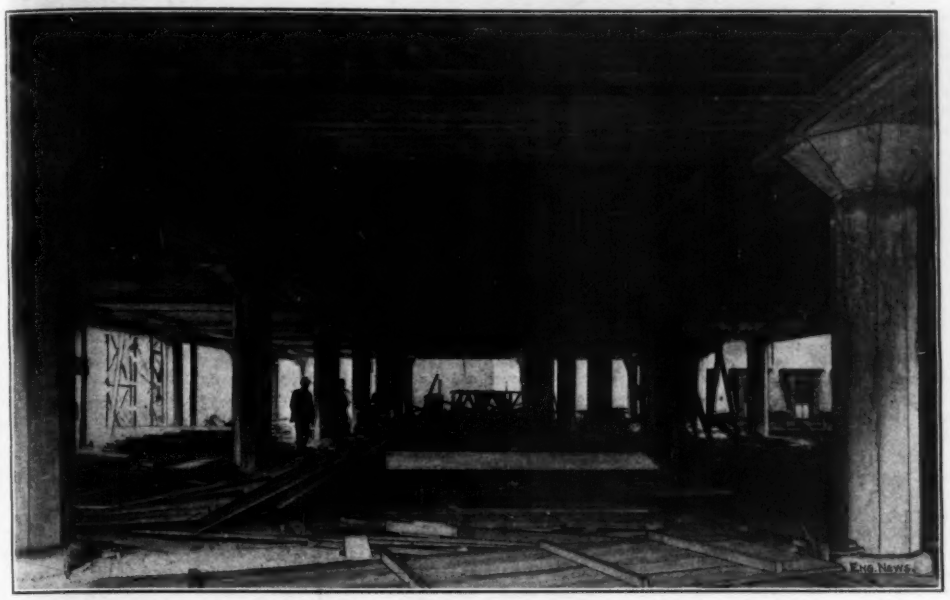

FIG. 2. VIEW INSIDE BUILDING, SHOWING PANELED SLAB FLOOR SYSTEM.

per surface. Between the testing platform and the surface of the model was introduced a rubber diaphragm filled with water and connected with a standpipe. By raising and lowering the head of the water in the pipe, loads were put upon the model, varying from 0 to 970 lbs. per sq. ft. Deflectometers were used to measure the deflection of each of the four panels, by means of which it was possible to measure the deflection to 1-1,000-in. without difficulty. The models reproduced construction designed for safe loads of 150 lbs. per sq. ft. The dead weight of the floor, in full size, averaged about 85 lbs. per sq. ft., hence, the dead load and "safe live load" together equaled 235 lbs. per sq. ft. With a factor of safety of three, the theoretical ultimate strength of the construction would be 705 lbs. per sq. ft. In models of this kind, the carrying capacity of the models should be the same as the carrying capacity of the floor construction; that is, the model, although of one-eighth the size, should be capable of carrying as much load per sq. ft. as the actual floor and not one-eighth of the load. It is, therefore, interesting to note from the deflection diagrams, that while these models carried, with only a few cracks and no sign of collapsing, as much load as we could put on with our apparatus (970 lbs. per sq. ft.), they showed marked changes in the deflection curves after the loads exceeded 700 lbs. The study of the tests of these models has been of great assistance in determining the proper method of analysis of the stresses in this construction, and also confirmed us in the correctness of our original analysis.

This design comes under the fifth type, the floor "slab without girders or beams." Its first practical application was in the reinforced-concrete construction we designed for a building for Hirsh, Stein & Co., at Hammond, Ind. These floors were designed for a safe working load of 400 lbs. per sq. ft. in addition to the dead load. The columns are 15 ft. apart. As the building is used for the manufacture and storage of fertilizer, no attempt was made to make it ornamental. The floors are carrying daily the full 400 lbs. live load for which they were designed, and probably this is frequently exceeded.

This brings us to the seventh type of construction, "the paneled slab without girders or beams," which is especially adapted for business and manufacturing buildings. It was used in the construction of the Studebaker Building, Michigan Ave and 21st St., Chicago, which is to be used for the sale, storage and repair of automobiles by the Studebaker Bros. Mfg. Co. We designed the reinforced-concrete portions of this building as consulting engineers for the architect, Mr. William Ernest Walker, of Chicago. The building is seven stories high above the sidewalk, with a basement 8 ft. 6 ins. clear under the ceiling, as shown in Fig. 1. The foundations are concrete piers, carried to bed rock, 90 ft. below grade. The first and second stories have practically uninterrupted show windows on the two street frontages, while the other stories have brick curtain walls trimmed with stone, and broken by groups of large windows. The reinforced-concrete wall girders are faced with brick so that no concrete appears on the exterior. The eighth floor forms a temporary roof, provision having been made for continuing the building several stories higher in the future.

A typical interior view is shown in Fig. 2, from a photograph taken just after the forms were removed from under the ceiling. The column spacing is unusually great, being practically 24 ft. each way, making the diagonal distance between column centers about 34 ft.

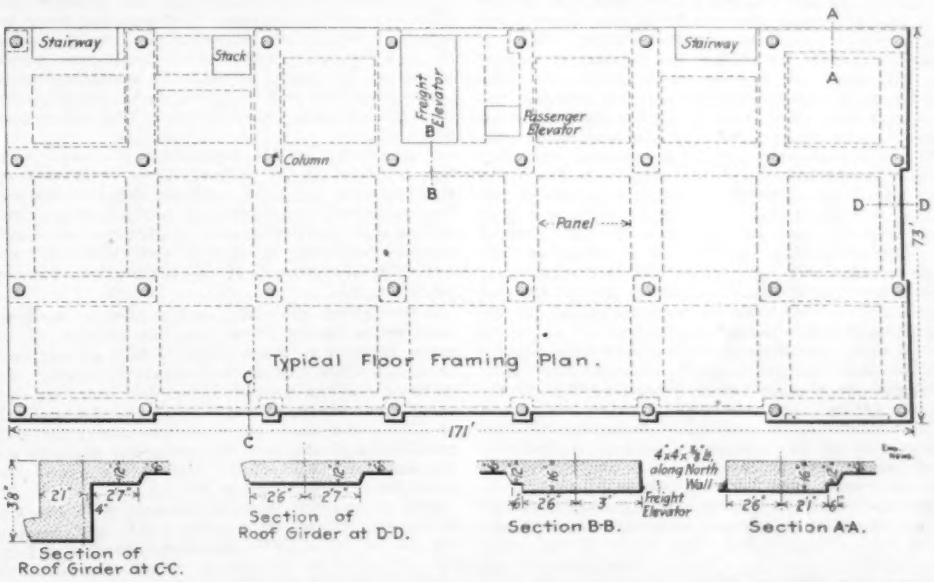

FIG. 3. PLAN AND DETAILS OF FLOOR FRAMING FOR THE PATENTED PANELED FLOOR CONSTRUCTION.

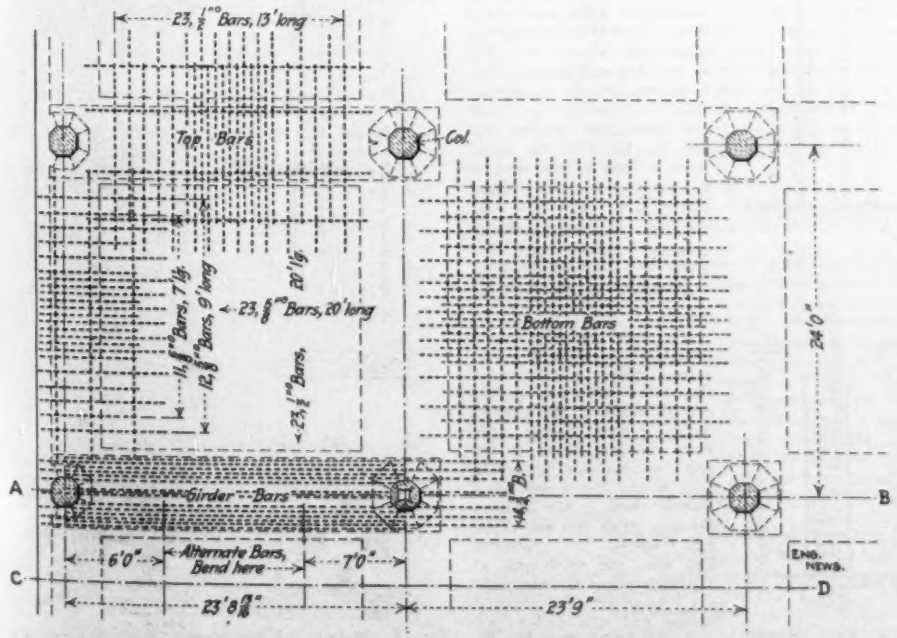

FIG. 4. DETAILS OF SLAB REINFORCEMENT.

The construction consists of continuous and paneled slabs, supported upon flaring column heads. The advantages gained by this paneled-slab design are: (1) An improved form of construction whereby great strength and carrying capacity are attained with an economical expenditure for material and labor. (2) A construction in which the stresses due to dead weight and all applied loads can be accurately determined. (3) A minimum depth of floor and a consequent reduction in the height of the building. (4) An improvement of the illumination of the rooms by the elimination of dark ceiling shadows. (5) A reduction in the expense of installing a sprinkler system.

A design was made for the same building, using reinforced-concrete girders, beams and slabs. The same clear story heights were provided in both designs. This is shown in Fig. 1, in comparison with the adopted design. The excavation for the basement is 18 ins. less for the adopted design, and the height from the sidewalk to the surface of the eighth floor is 93 ft. 8 ins., as compared with 104 ft. 2 ins., or 10 ft. 6 ins. less for the adopted design than for the other. Fig. 3 is a typical floor plan of the building, showing the arrangement of the columns, stairs and elevator openings. It will be noted the adopted design has columns with widely flaring heads or capitals surmounted by square caps. These column heads and caps support and form a part of a platform or slab which may be of uniform thickness or may be paneled

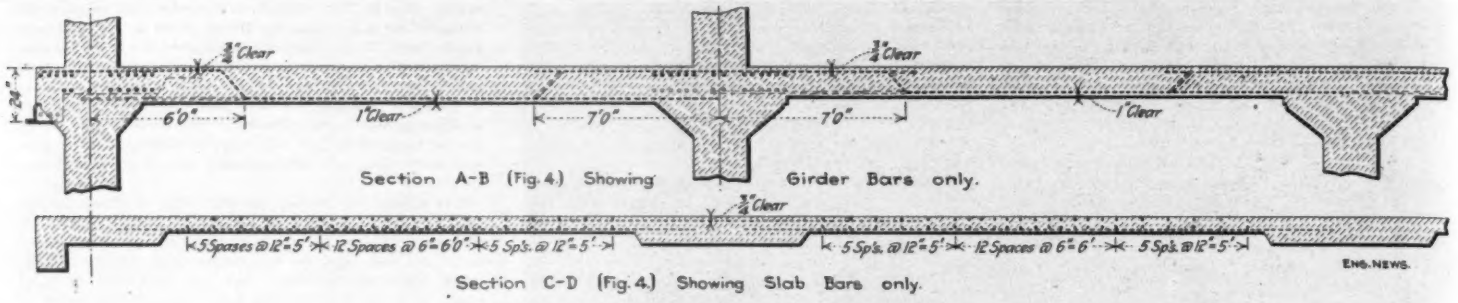

FIG. 5. SECTION THROUGH FLOOR SLAB.

(as in this case) to reduce the thickness in the center. But for purposes of calculation and design, the floor and ceiling consist of intersecting slabs, having widths equal to, or slightly greater, than the extreme width of the column caps, these intersecting slabs in turn supporting enclosed slabs. In this construction, whether the floor is made of uniform thickness or is made thinner in the center, the manner of reinforcing and supporting it is the same.

This method of reinforcing the floor construction is exceedingly simple and direct, and is clearly indicated in Figs. 4 and 5. The longitudinal reinforcement of the intersecting slabs consists of ¾-in. and ⅞-in. square steel bars. These bars are bent so as to reinforce the under side of the intersecting slabs between the column supports and to reinforce the upper face of these slabs over the column supports and for a considerable distance each side of the column in order to provide for tension due to negative moment in this region. In addition to the longitudinal reinforcement, the intersecting slabs are reinforced laterally near their upper faces, by ½-in. round bars which extend across the full width of the intersecting slabs and a considerable distance into the enclosed slab. This lateral reinforcement serves a double purpose: (1) reinforcing the intersecting slabs against bending laterally, and hence, the loads from the enclosed slabs are distributed over and carried by the full width of the intersecting slabs instead of being carried by their adjacent edges only; (2) taking care of the tension in the upper face of the enclosed slab due to negative moment, thus restraining these enclosed slabs and reducing the positive moment in them.

The lower reinforcing of the enclosed slabs consists of two layers of ½-in. round bars placed at right angles to each other (spaced closer together in the middle portion) near the under face of the slab to fully reinforce it for tension due to positive moment. These slabs are also reinforced around their sides, near their upper faces by the ⅛-in. bars already referred to, for tension from negative moment.

An important feature of this design is the combination of the column heads with the intersecting slabs, whereby the depth, and hence the strength, of the slabs is greatly increased in the region of greatest negative moment, namely at the supports. Between the column heads the intersecting slabs have their upper faces supplemented by the concrete in the enclosed slabs, and, therefore, they may be considered as having a wide T section, thus increasing the strength of the slab to resist the compression due to positive moment between the column heads. The wide column heads, of course, reduce the clear spans of the intersecting slabs.

By paneling the ceiling in its middle portion, a great saving is made in material and, hence, in the dead weight, over what would be necessary if the entire slab were of uniform thickness.

This construction is so designed that wherever possible it is made continuous over supports, hence the deflections and stresses are much less than is the case for non-continuous construction. It is this feature which can be secured so easily in reinforced-concrete construction that makes it possible to greatly reduce the depth of beams and slabs where they are properly reinforced.

It is possible in this construction to provide openings anywhere in the enclosed slabs, or to omit the enclosed slabs altogether, without thereby weakening the construction in any way. Or any one of the intersecting slabs may be changed in position, thus readily providing openings for elevator and stair wells, and still leave the stresses in the construction determinate.

In the girder and beam design already mentioned (and shown in Fig 1) a 4-in. slab is supported by beams spaced 8 ft. apart, which in turn are supported by girders connecting to the columns as shown. The girders are 23 ins. wide by 26 ins. deep under the slab, or 30 ins. over all, and the beams are 11½ ins. wide by 22 ins. deep under the slab, thus making the maximum depth of the floor for the typical panel 30 ins. The maximum depth of the floor of the typical panel of the adopted design is but 12 ins.

Both of these designs were calculated for a live load of 100 lbs. per sq. ft. and for the bending moments for beams and slabs and the unit working stresses for concrete and steel allowed in the proposed revised Chicago building ordinance. That is, the moments for beams and slabs were calculated as ($WL^2 \div 12$) for intermediate spans, as ($WL^2 \div 10$) for end spans. The maximum allowable compression in concrete in bending was taken at 100 lbs. per sq. in. and the maximum tension in the steel at one-third of the elastic limit, or 17,000 lbs. per sq. in. The maximum shear or diagonal tension in concrete without reinforcement was taken at 40 lbs. per sq. in.

The quantities of concrete and steel in these two designs, taking into account the extra concrete in the column heads in the adopted design, are nearly the same, in fact there is 6% less concrete and 3% more steel in the girder and beam design, than in the adopted design. With the prevailing unit prices for concrete and steel the total cost of materials alone is practically the same for the adopted design and the girder and beam design. But in the cost of formwork and of placing the steel and concrete there is a great saving in favor of the adopted design. The greater simplicity of the formwork required for the adopted design over the girder, beam and slab design can be seen by comparison of the drawings in Fig. 6.

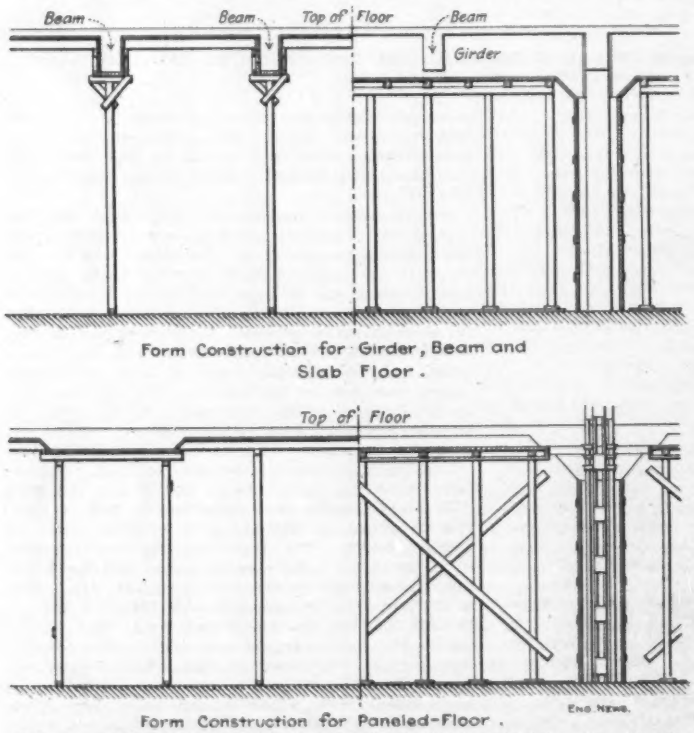

FIG. 6. COMPARATIVE FORM FOR ORDINARY GIRDER AND SLAB CONSTRUCTION AND THE PANELED SLAB SYSTEM.

The columns in the Studebaker Building are of the Gray type and are built up of eight steel angles and plates riveted together as shown in Fig. 7 and surrounded by concrete. The steel is designed to carry the full load in the lower stories without taking into account the concrete. According to the requirements of the building ordinance, structural steel columns with milled and spliced joints, when enbedded in concrete and surrounded by concrete, may be designed on the basis of allowing a stress in the steel of 18,000 — 70 L/R, but never to exceed 16,000 lbs. per sq. in. If the concrete is assumed to carry part of the load, then stress in the steel is not to exceed 15 times the stress in the concrete. Without hooping the columns, the stress in the concrete is not to exceed 500 lbs. and the steel 7,500 lbs. per sq. in. The basement columns carry nearly 1,000,000 lbs. each and have approximately 60 sq. ins. of steel. The seventh story columns are designed as reinforced-concrete columns. In these columns steel T-bars replace the angles. This particular type of column is not essential to this construction.

The reduction in the height of buildings gained by adopting a floor and ceiling construction of this type, without beams or girders, results in effecting a saving in (1) walls and columns, (2) in equipment for elevator, heating, plumbing, sprinkler systems and lighting, and (3) in the usual expenditure for elevator op-

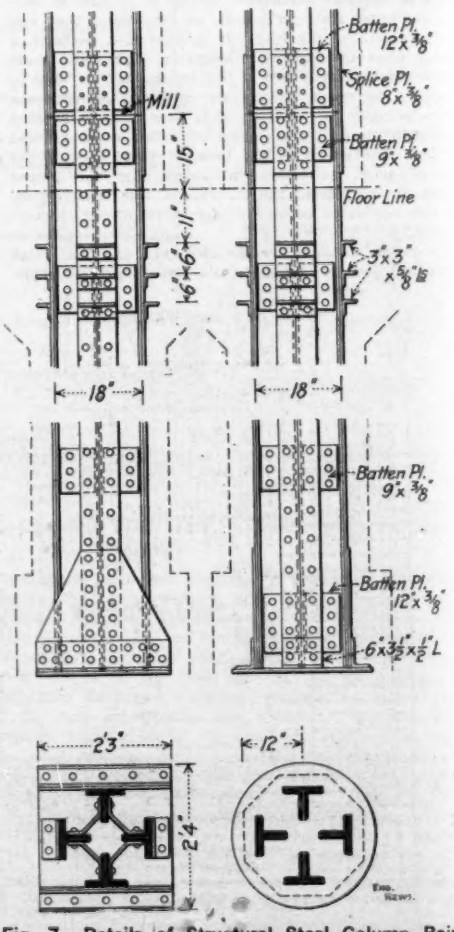

Fig. 7. Details of Structural Steel Column Reinforcement, Studebaker Bldg., Chicago.

eration and for heating. By the elimination of deep girders and beams, the lighting of the rooms is greatly improved and, therefore, there is a saving in the cost of illumination. These benefits are also obtained by other forms of flat construction, but two marked advantages of this construction over other designs are: (1) that the stresses due to the weight of the structure itself, as well as loads to be carried, are determinate and, therefore, designs for this construction can be made with the same assurance as to their strength that is demanded for designs of railway bridges and similar structures; (2) by paneling the ceiling and thus making the slab thinner in the middle, the amount of concrete and consequently the weight of the structure to be carried by the columns is greatly reduced. In the case of the Studebaker Building, the reduction in the dead weight amounts to over 3,500,000 lbs.

These several advantages are gained without sacrificing architectural appearance, for the architectural effect of this construction is pleasing, presenting a happy combination of the lines of strength and beauty.

Is the Engineer School Necessary?*

By R. R. RAYMOND.†

A doubt having been expressed informally as to the usefulness of the Engineer School, or any service school, a few thoughts on the subject may not be amiss. This paper does not pretend to cover the whole question or to settle any part of it. It simply throws a few side lights on the matter.

When there is work of any kind to be done, it will be done best and most economically by a man who is properly equipped and trained for the purpose. This may be accepted as axiomatic; but to emphasize the point, as well as to determine what constitutes proper equipment and training, let us take a simple illustration.

You wish to have a set of shelves built in your office. You summon a carpenter, who comes and examines the contemplated job, gives you an estimate on it, goes and gets the necessary tools and material, and in a reasonable time completes the work. You find that your shelves present a neat appearance and show good workmanship. You are satisfied and pleased with the workman. You care nothing whatever about his ability as a mathematician, a writer, a theologian, or even an engineer. So far as your wants are concerned, he is a trained (that is, an educated) man.

A friend drops in and tells you that he wishes you to recommend a carpenter to build him a cupboard. You reply that you know a man who has just made a good job of a set of shelves. You have never seen him build a cupboard, but you feel sure that he has the necessary tools and skill to do so, and you confidently recommend him for the higher job.

Now this seems to be a very simple and sensible proceeding. There is nothing at all remarkable about it. Anyone has sense enough to do the same thing. The same rule applies in all the walks of life. But does it? Do we select our trained men for the work of the army in this sensible way? Do we not proceed more as follows:

The carpenter arrives with nothing in his hands. We are astonished at this, and we ask if he has no hammer. He replies that it is in his tool chest, where it belongs. Dear, dear! it should be somewhere on his person. Has he no saws, no planes, no square, no screwdriver, no chisels, etc.? He says that he has, but they also are in their proper places in the tool chest. We are grieved at this and fear that he is not properly equipped for the work in hand. Then, too, a friend of ours intends to build a cupboard which will involve the use of beading and molding. Has the carpenter the special tools for this? Has he a mortising machine? Why, no, certainly not. If he fills his chest with tools which are of infrequent use, he only makes it the more difficult to get at the more important tools in the chest; and, besides, it is more economical to have such work done at the mill. We fear that we can not employ him, as he is not provided with all the tools required to meet possible needs. In vain he points out that when special cases arise he has sense and knowledge enough to go and buy the proper tools, and that if he were to carry upon his person all kinds of tools used in his business he would only crush himself to the earth and be unable to perform any work at all. But no; he is not fully equipped. We can not accept him.

This may appear to be overdrawn; but it is a close parallel to what is done in the army. Not two years ago the writer was ordered to report to a board for examination to determine his fitness for promotion. He began at once to prepare for the ordeal. How did he go to work? By inviting attention to the shelves he had built? Not at all. He made lists of all the tools which the board in similar cases had insisted should be carried upon the persons of all carpenters who aspired to the construction of cupboards, and he proceeded to attach them to himself for the inspection of the board. (Observe, please, that facts and knowledge are the tools of the engineer, just as woodworking implements are the tools of the carpenter.) Many tools fell off daily, but he hastily hung them on again, until on the appointed day he presented himself for inspection with the most absurd, ridiculous, and preposterous assortment of tools imaginable heaped upon him and dangling from all his parts.

Owing to distance, the board could not inspect him in person, but prepared a list of tools which he was to exhibit and describe under the direction of a designated officer, and which were to be accepted as representing the whole museum. (In other words, the examination was written.) For ten long weary days he exhibited and described the tools demanded. They formed but a small part of the collection that he had assembled and under whose weight he was barely able to stagger and entirely unable to work. At last the exhibition was over. The board solemnly pronounced him properly equipped to build cupboards. As a matter of fact he could not have built a cupboard then to save him. The load he had borne was too great and the exhaustion too severe. He threw away his burden, confident that most of it would never again be needed and that the rest could be picked up again when desired; but it was several weeks before he had recovered sufficiently to build as good a cupboard as he could have built before he overtaxed his back. There is nothing unusual about this case. It is perfectly typical.

Right here is the proper place for the reader to ask how it is possible, then, to be sure that a man has the proper education for his position. How can a military engineer be trained if he does not acquire all the tools of his profession and keep them always at hand?

To answer this question, let us again consider the carpenter. How did he acquire the skill which enabled him to make a good job of the shelves? Without doubt he began work in his youth under the guidance of an older and more experienced man. By seeing how this preceptor performed his work, he learned to do likewise. He also learned by experience just what tools it was best to keep always available in his tool chest, and how to keep them in the best condition for use. His tools were always a means to an end, never the end itself. Being a man of character, and ambitious, he applied his inventive faculty to improving upon the methods of his teacher, and he naturally became interested in the ideas of others bearing upon his trade. He was familiar with the various special tools which he saw in the hardware store or illustrated in catalogues, and he knew where to obtain such tools in case of need. There could be no question as to his ability to use them, for the knack of using tools is not confined to those alone which are most frequently used. He thus trained himself to perform not only those works which were of daily occurrence, but also those which demanded resourcefulness. The moral is that the ability to do work is acquired by doing it; and doing simple work stimulates the worker and assists him to advance to higher undertakings. No amount of study and theory will produce this result.

Were it possible to take those graduates of the Military Academy who are assigned to the Corps of Engineers and place them at once under the care of older officers on works where they could see how the tools of the profession should be used, and where they could themselves acquire the use of those tools; or, were it possible, to assign them to companies under experienced captains where they could acquire all the tools of the military branch of their profession; this would produce more efficient officers for both military and civil engineering duties than any amount of instruction in the best equipped school.

Again the reader bobs up with an inquiry as to why this is not done. Why equip and maintain an expensive Engineer School if it is not the best way to train our officers?

The answer is prompt. It is the best way available. We are actually sending the young officers to duty under experienced men, but a year is about the longest time that can be spared, and is too short. We have too few officers to assign the young ones for several years to works already properly administered by older men. In many cases the young and inexperienced must control without the guidance of the experienced. Under present conditions, our captains are themselves inexperienced and but little older than their lieutenants. That they acquit themselves as well as they do is highly creditable to them; but they are not old enough to undertake the training of young officers, and the system falls to the ground.

Let us suppose that our young carpenter finds himself at the outset called to a place far removed from the experienced man who was to have trained him. What can the latter do to increase the young man's chances of success? He would probably assist him to select an assortment of those tools which he should always have in his kit, at the same time giving such advice as to their use as the time would permit; and he would give him a catalogue of special tools which he could order later if necessary. This instruction would be very different from the full training which was to have been given, but the young man would go out into the world much better equipped than if he had been left entirely to his own resources. If he is the right kind he will succeed anyway, but starting him on the right road makes his success easier and more certain.

The function of the Engineer School should be exactly similar. The burdens of the Corps of Engineers are steadily increasing, while the time available for the preliminary training of young officers is as steadily decreasing. A few years ago it was three years, and it was then rarely broken into. Now it is only two years, and the students are assigned to all kinds of duties that interfere with their school work or interrupt it entirely. To-day a young officer is apt, nay quite sure, to be entrusted with important duties. If he knows what tools to use, he will be less apt to make mistakes. If he is the right kind, and most of them are, he will make good anyway; but he will succeed more surely and with less effort if he is given a proper start like the young carpenter. Mistakes in modern engineering are very costly, and good sense demands that every possible precaution be taken against them. If allowed to perform its proper function, the Engineer School is of the highest value and practically indispensable.

The great danger to this School and to the Army is thought to be the tendency toward the belief that the education of the Army is in itself an important thing, whereas it is really of no importance whatever except in so far as it enables the Army to do its work better; and that keeping the Army always at school is the same thing as educating it. At the Engineer School we should give to the student officer the kit of tools which he will need for everyday use, show and explain the more intricate tools which he may have to use in special circumstances and tell him how to get these special tools, and then send him out into the life of the service to make good through his own character and energy. The business of life is work and accomplishment. A certain amount of preparation is wise and necessary; too much is a waste. A man could spend his whole life in the endeavor to learn everything bearing upon his profession, and at the end of that life find that his object had failed and that he had accomplished nothing useful. Not only is this true, but after a certain amount of preparation, the power to use the acquired knowledge is lost. Just as the carpenter who attempts to carry his kit all the time can do little work under such a burden, so the professional man can overload his brain so that it can not work. The musician who practises too much may become paralyzed. The athlete who trains too much may become stale. The student who attempts to learn too much may injure his mind. The same rule holds true in everything.

The whole Army is now at school to the great detriment of its proper work. If every man is able to do his work, and does it, what more can be asked? Why is it necessary that every private shall be trained to be an officer and every officer a general? What can be more appropriate than that every captain shall be engaged in training his company or troop and preparing it for service? This is a work that demands all the intelligence, energy, and time of an able man. How many captains are permitted to do it, however? Are they not rather preparing themselves to be generals? What is wrong with the Army? This is the oft repeated cry. The answer comes: There is nothing wrong with the Army; it was never more efficient than at present. This sounds well, but it is not true. There is something wrong. Every one feels it, this spirit of unrest. The trouble is that we are staggering under our kit of tools and are not doing our work. What is worse, we are losing the power to do it. Would it not be wiser to take the Army out of perpetual school, put it on its own job without distraction, let it learn to use its tools through use and not by holding them up for inspection? Only then will it be a happy and contented Army and a truly educated and efficient one.

Under no circumstances should a company officer be taken away from his company, nor should he be nagged by any school or duties not directly connected with his command. Every particle of his energy is needed to instruct and care for his men. This is the highest and most important duty of a captain. It is recognized in the Army Regulations, but is not in practice accorded its real weight. When the company goes into the field, which is the more important, that the captain shall be qualified to command the regiment (theoretically) or that the company shall do its work? If the captain spends two or three years detached from his command, listens to lectures, rides over historic battlefields, exhausts his energies in study, and learns to think himself ill, how doth it profit the company? How many companies and troops are to-day captainless while their captains are at school?

Should we abolish the schools then? Not at all. They are very valuable if kept in their proper places; but it should never be forgotten that they are a means only. They are of absolutely no importance in themselves. A few officers can well be employed in recording, com-

*From a paper in "Professional Memoirs" of the Engineer Bureau, U. S. A. The "Engineer School" to which the author refers is the school for the instruction of engineer officers after their graduation from West Point.

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piling, and publishing the advances in military science; but it will rarely be the case that any advance comes from an officer on duty at a school. This is not his fault; his brain has no opportunity for original work. The most certain way to prevent a man from inventing anything useful is to keep him busy with matters other than the problem in hand.

These observations apply to all arms of the service, but just now we are especially concerned with their application to the Corps of Engineers. We need trained officers. To train them we must occupy them with their own work and as little else as possible. Experience is by far the best of all teachers, but, unfortunately, we are expected to be trained in a field that is broader than any one man's experience can possibly be. The Engineer School comes to our rescue here; but to be of real value it should give each man his outfit of knowledge and send him out to real life in the least practicable time. He needs a working equipment and not an encyclopaedic education. To give him this equipment quickly, so as to secure to the Government the benefit of his useful services, the school should have every facility. Its instructors should be allowed to perform their functions without other duties. This is now provided for on paper, but the powers that be respect it not at all.

The School should have adequate buildings where the laboratories, model rooms, and library could be worked to their utmost capacity. An hour in a model room, such as we could have at the Engineer School, is worth weeks of hard reading. With half a show we could have a school that would really fit our young officers for their life work. Under present conditions it may be doubted whether the results justify the effort. Both instructors and students are overloaded with extraneous duties, or whisked away entirely for all kinds of jobs. The classes are not permitted to progress together throughout the course, but are broken up so that the members graduate months (sometimes years) apart. The Engineer troops are sacrificed by taking their officers away to attend the School, and then the School is disabled by sending its instructors and students to duty with the troops. We are trying to serve two masters, each of whom independently expects to have all our time and energy.

The Engineer troops are a vitally important part of the Army. They should have their full complement of officers and every opportunity to perfect themselves in their own sphere of action. Nothing should be permitted to interfere with their training or the discharge of their proper functions. They should be supplied with officers regardless of all other demands upon the Corps of Engineers. Other duties, civil duties, duties of high importance, have been assigned to the Corps in order to make it possible to maintain a body of trained engineers for use in war. These duties afford a training which is of the greatest value, and the efficiency of the Corps would be seriously affected if we were to be separated from them; for that would amount to taking us away from work and sending us back to school to keep us busy. It is manifest that in time of peace the military engineer can not find real employment for his profession, and it is equally clear that practice as a civil engineer is excellent training for the doing of any kind of engineering work. On the other hand, the School is of real importance, and should receive its just consideration and dues.

The problem in a nutshell is this: Given a certain number of officers in a corps of engineers, is it possible by separating some of them from the proper work of the corps, and placing them in a school, to improve the efficiency of the corps as a whole, so that the amount of work accomplished is increased or its quality bettered?

The writer believes that it is practicable and advantageous to do this. If this belief is correct, then there must be some definite relation between the corps and the school, which should fix the proportion of the corps to be employed at the school to give the maximum efficiency. If no officers go to the school, all will be available for work. If one man can be employed at the school in collecting, compiling, and publishing professional information, so that through such information the corps is enabled to accomplish more than it could do without the information, but with that officer in his normal place, then the school is useful. If two men at the school can secure a still greater efficiency of the corps, then the school should be increased to two; and so on. After the proper number of officers to collect and dispense knowledge has been determined, a further problem arises. Can the efficiency of the corps be further increased by sending a number of officers as students to the school for a time? If so, how many should go, and for what time?

Greater wisdom than the writer's is needed to answer these questions; but it is safe to say that the shorter the time necessary to impart the desired education the better for the work of the corps, and this time can be shortened for a given standard of education only by means of the best equipment and other facilities and by rigidly enforcing the principle of non-interference with the school by other interests.

Work of the New York Public Service Commissions.

The New York Public Service Commissions have presented to the legislature reports of their work for 1909. Summaries of those features which most interest engineers are presented below.

The First District Commission: Public Utilities in Greater New York.

During the year, the Commission has held 111 meetings for the formal consideration of matters before it, and 160 meetings as a "Committee of the Whole" for preliminary and informal consideration of business. It has considered 271 formal cases, holding 513 hearings and has handled informally 1,335 complaints relating to railways and 318 relating to gas and electric companies. The following paragraphs relating to the volume and density of traffic in Greater New York are of special interest:

	1908.	1909.
Total number of accidents on street, "L" and subway and steam railroads within New York City	56,481	52,618
Number of persons killed	444	325
Number of persons and vehicles struck by cars	11,405	11,426

The service rendered by transportation companies is now better than ever before in proportion to the physical conditions and the volume of travel. Due to the orders of the Commission, the maximum service is continued for a much longer period than heretofore, and the rush-hour service has been increased. Upon the Manhattan surface lines, for example, as to which service orders have been issued, a comparison of service rendered before and after the orders shows an increase varying from 11% to 37%.

The matter of adequate service is a serious problem, for during each 24-hour period passengers equal in number to about 85% of the entire population must be carried. Fully one-third of all the passengers traveling in one direction during the day are carried in two hours out of the twenty-four.

An annual count is made of the number of persons who cross the East River between Brooklyn and Manhattan and return during a 24-hour period. The following schedule shows the figures of travel in both directions for three years:

Routes.	Travel to and from Long Island, 1907.	Travel to and from Long Island, 1908.	Travel to and from Long Island, 1909.
Brooklyn Bridge	423,000	309,783	323,006
Williamsburg B'dge	163,000	183,233	206,606
Queensboro Bridge	.....*	.....*	26,300
Ferries	120,000	175,749	120,841
Interboro. Subway	.....*	159,708	193,784
Total	706,000	827,473	870,537

*Not open for traffic.

The figures in Table I. indicate the extent of the transportation problem in New York City:

One important department of the Commission's duties is the supervision of the Rapid Transit lines and the construction of extensions to the underground railways of New York City. Station enlargements in upper New York City costing nearly a million dollars are in progress. The subway express cars are being equipped with side doors and the station platforms are being lengthened to permit the running of 10-car trains instead of 8-car. These alterations will greatly increase the traffic capacity of the present subway. Contractors are at work on the Fourth Avenue Subway in Brooklyn. The present Rapid Transit system has a total length of 25.82 miles. The additions now under construction will add 5.4 miles. Besides this the Commission has nearly completed plans for the Broadway and Lexington Avenue system in Manhattan, the Broadway-Lafayette Avenue route in Brooklyn, the Canal Street line in Manhattan, and extensions of the Brooklyn system to Fort Hamilton and Coney Island, a total of 37.77 miles of road. The Commission expects to invite bids on these additional lines early in 1910.

The Commission calls especial attention to the need of legislation for the elimination of grade crossings. In the Borough of Queens there are more than 300 grade crossings of the Long Island R. R., and 29 deaths occurred at these crossings in 1908. The existing law provides a method of altering single crossings only, while track elevation or depression for long distances is the remedy which should be applied. In the Borough of Richmond there are about 100 grade crossings of steam railroad lines. These boroughs are being rapidly built up and it will be vastly more expensive a few years hence to make changes in street grades made necessary by grade crossing removal than at the present time.

Court decisions have "devitalized" the power of the Commission under the law to prevent stock watering, to regulate rates and service and to prevent construction under franchises that do not safeguard the public interest. The Commission therefore urges additional legislation to effect the purposes contemplated by the legislature in the original passage of the Public Service Law.

The Second District Commission: Steam Railways and Public Utilities in New York State.

The "Up-State" Commission has jurisdiction over 811 public utility corporations, of which 186 operate steam railways and 139 street railways. The steam mileage is 8,164 miles, and including all main yard and siding tracks, 16,477 miles. The electric railroad mileage is 2,744.54 miles. The aggregate results of the operation of steam railroad corporations reporting to the Commission for the fiscal years ending June 30, 1907, 1908 and 1909 are given in Table II.

It will be seen that the net earnings of the year ending June 30, 1909, showed a very large increase over preceding years, and that even in 1908, when railways generally were currently supposed to be suffering from hard times, the railways of New York State earned larger profits even than in the boom year of 1907.

The following table for electric railroads gives the same information for electric railroads as the preceding table for steam railroads:

	1907.	1908.	1909.
Gross earnings from operation	$19,293,052	$21,194,486	$21,919,652
Per cent. of increase over preceding year.	15.9%	9.85%	3.4%
Expenses of operation	$12,471,755	$14,129,150	$14,647,399
Per cent. of increase over preceding year.	17.7%	13.3%	3.7%
Net earnings from operation	$6,821,197	$7,065,336	$7,272,253
Per cent. of increase over preceding year.	12.8%	3.6%	2.9%
Passengers carried	427,520,000	451,388,415	462,455,932
Per cent. of increase over preceding year.	11.4%	7.2%	3%
Total dividends paid during the year	$1,659,157	$2,065,242	$2,965,206
Total number of corporations, all classes			310
Total number paying no dividends			237
Total number paying dividends			73
Amount of common stock paying no dividend			$126,956,530
Amount of common stock paying dividend			53,859,074
Amount of preferred stock paying no dividend			15,317,400
Amount of preferred stock paying dividend			18,461,072

The Commission says the very remarkable showing made by these tables and summaries demands but little comment from the Commission at this time. Attention should, however, be directed to the fact that they have no wide range of use except by way of suggestion for investigation. The significance of the facts which they disclose depends wholly upon the further fact not disclosed whether these stocks represent actual cash investment in the properties of the several corporations or whether they are lacking in that particular characteristic.

It is common belief that the plants of the public service corporations included in these tables have been constructed, as a rule, upon the bond issues, and that the common stock, at least, is representative only of hopes entertained. The precise truth with regard to so many corporations, many of which are the product of reorganization, it is difficult, if not impossible, to ascertain. The intervention of construction companies to which a lump amount of stock and bonds has been issued for construction, makes a clear showing of what has been paid for with stock and what with bonds, or how much has been realized for the stock, impossible.

The general fact is believed to be beyond dispute, although it may not be susceptible of legal proof in many cases, that in launching public service corporations prior to the regulation of capitalization by the State, it has been thought that capital could not be enlisted without the aid of large bonuses in the form of stock upon which returns could be had either by way of dividends or by sale to those seeking an investment. It has been feared, unquestionably, that the regulation of capitalization by the State and insistence by the Commission upon the law, that capital stock should be issued only for full par value in money, property, or services, would hinder, if not prevent, the further growth of such corporations by making them unattractive as business enterprises. Upon this point certain observations seem pertinent.

If the stock of non-dividend-paying corporations represents no actual investment of money, and was in its inception issued merely as a bonus or gratuity in connection with the promotion of the enterprises upon the expectation that it would yield profits and thus become

TABLE I.

Year ending June 30:	1907.	1908.	1909.
Number of operating companies:			
Street or electric railway	29	30	33
Steam railroad (Staten Island)	2	2	2
Miles of (single) track	1,597	1,636	1,646
Number of passenger cars	10,062	11,049	11,623
Number of officers and employees	34,113	39,839	37,609
Miles run by passenger cars	252,783,198	273,788,406	272,389,956
Revenue passengers carried	1,322,816,965	1,365,169,472	1,400,132,118
Revenue passengers per day	3,624,156	3,729,971	3,860,635
Revenue from transportation	$66,838,721	$68,461,349	$70,732,928
Total revenue from rail operations	68,318,881	69,941,968	73,646,417
Total expenses of rail operations	37,779,099	43,087,446	44,022,578
Net revenue from rail operations	30,539,782	26,854,522	29,623,839
Operating ratio	55.3%	61.6%	59.8%
Per car mile:	(cents)	(cents)	(cents)
Revenue	26.1	25.3	26.8
Expenses	14.1	15.6	16.0
Net revenue	12.0	9.7	10.8

of substantial value, the table demonstrates the fatuity of any such expectation.

If the stock was a bonus or gratuity to those to whom it was issued, but has been transferred to holders, for a valuable consideration, who made the purchase as an investment, the table is a warning against dealings in stocks issued for no value, representing no property, and having no prospect of a return except from unreasonable charges.

If the stock represents actual investment, then there is grave reason to consider what is wrong in the condition of public service corporations in this State that they cannot earn returns upon such enormous sums of money invested in them.

Any system of law which permits uninstructed investors to place their money in stocks of public service corporations which either ought not to or cannot yield any return, and which, in fact, are nonproductive, is distinctly injurious to the noninvesting as well as the investing public. Eventually capital will learn by experience the actual results of such financing and will carefully avoid enterprises thus handled.

The value of the tables presented lies in their conclusive demonstration that, broadly speaking and taking the corporations included as a class, such corporations have either been financed by methods which the event has shown to be disastrous or they are now operating under conditions which need careful investigation.

The enemies of the Public Service Commission have persistently harped on the idea that the Commission's control over the issue of new capital and other construction of new railways and other public utilities would put a bar upon development. It is an excellent commentary upon this criticism that the Commission during the past year has granted authority for the issuance of $142,855,035 of stocks, bonds and other evidences of indebtedness, making a total of $252,839,681.34 authorized during the thirty months of the Commission's existence.

Gas and Electrical Corporation Supervision.

Gas is now furnished in accordance with the illuminating power requirements, which the investigation discloses serve as a standard for probably not more than 20% of the entire output, the proportion used in open-flame burners. The balance of the supply is either burned in mantles or consumed for domestic and industrial fuel purposes, and in all of these uses its heating value, rather than its illuminating value, is of primal importance. Upon the information at hand as to the situation, the Commission has invited representatives of the companies and gas engineers to meet with it in conference on Feb. 1, 1910, to consider the necessity of fixing a calorific standard. The authority so to do, however, must first be obtained from the Legislature.

The year's tests of gas for illuminating power and purity afford just grounds for criticism of many of the supplying companies. Either in candle power or the presence of impurities 38% of all the tests, 887 in number, showed deficiencies. Examination made of 33 plants revealed that in most instances the failure to comply with existing standards is very largely due to either improper gas-making equipment or to censurable methods of manufacture.

During the year 98,895 gas meters were tested, of which 95,297 were verified and sealed as correct within the 2% limit of error allowed by law, and 3,598 were rejected. Electrical corporations have been required to make periodic tests of consumers' meters, using standards that are checked for accuracy by inspectors of the Commission; 78,116 electrical meters were tested, of which 69,000 were found accurate within 4%; 20% were found 4% or more slow and 11%, 4% or more fast. In the Commission's supervision of this work 1,744 electrical station standards were checked for accuracy.

Elimination of Grade Crossings.

Because of the failure of the legislature to make any appropriation for steam railroad grade elimination last year the Commission has been unable to proceed in the 65 applications for grade crossing now pending. During the year the funds on hand were exhausted by orders eliminating seven crossings in which the State is to pay its share. Since the Grade Crossing Law became operative there has been 233 crossings eliminated and work on 23 additional is now in progress. The entire amount expended by the State in the payment of its one-fourth share of such elimination and now obligated to be paid for work under construction is $1,617,606.92. The Commission says the lack of appropriation to carry on this work has not only seriously interfered with the State's policy to insure public safety at crossings, but also has undoubtedly acted to prevent both railroads and municipalities from presenting further petitions for grade crossing elimination. It is on account of this lack of funds that the Commission has been unable to make orders for grade separations at Bronxville, Scarsdale, Irvington, Tarrytown and Hartsdale, within the electric zone of the New York Central and Hudson River railroad, where conditions due to rapid suburban development and large growth of traffic on the streets and highways, together with the high speed and great number of trains on the railroads, render travel over grade crossings within this zone especially perilous.

Operation of Railroads.

The Commission's experts have visited 164 locomotive terminals at which repairs are made to locomotives. Special attention has been given to the inspection of equipment of the smaller railroads, as these roads do not as a rule have efficient repair staffs or facilities, and therefore require more frequent inspection than is necessary on the larger railroads where efficient supervision is generally given by the railroads' mechanical officers. The inspection of equipment on these smaller roads showed serious defects in some cases in the safety appliances, air brakes, and tender wheels. Recommendations were made covering proper repairs, renewals and methods of inspection, and these recommendations have been complied with.

Attention has also been given to the inspection of passenger cars on twelve of the smaller railroads, and a number of serious defects have been noted in the air brakes and safety appliances, in the method of fastening and guarding stoves, care of oil lamps, care of drinking water tanks, lavatories, and general sanitary conditions. The examination has indicated the advisability of making regular inspections of safety appliances, etc., of the passenger cars on the smaller roads.

The investigations into steam-railroad rail breakages showed for ten months in 1909, 2,575 breakages. The number for January, February and March, 1909, was 1,280 as against 3,408 for the corresponding months in 1908 and 3,014 in 1907.

TABLE II.

	1907.	1908.	1909.
Gross earnings from operation	$396,557,982	$402,317,818	$402,265,445
Per cent. of increase over preceding year	8.16%	1.45%	D 0.01%
Expenses of operation	$278,191,841	$282,410,002	$266,852,915
Per cent. of increase over preceding year	10.06%	1.51%	D 5.51%
Net earnings from operation	$118,366,141	$119,907,816	$135,412,530
Per cent. of increase over preceding year	3.88%	1.30%	12.93%
Tons of freight carried	265,609,000	248,750,958	247,652,000
Per cent. of increase over preceding year	6.69%	D 6.34%	D 0.44%
Ton-miles of freight carried	37,343,086,000	37,564,347,398	37,530,589,000
Per cent. of increase over preceding year	9.26%	0.59%	D 0.09%
Passengers carried	253,693,000	278,880,817	274,741,000
Per cent. of increase over preceding year	2.68%	9.93%	D 1.48%
Total passenger-miles	6,010,356,000	6,511,203,679	6,460,505,000
Per cent. of increase over preceding year	7.39%	8.33%	D 0.80%
Total dividends paid during the year	$32,107,722	$42,150,002	$39,216,300

D = Decrease.

The Commission supervises the inspection of 7,489 locomotive boilers, which is one-seventh of the total number in the United States.

In 1908, eight persons were killed and 22 injured by locomotive-boiler explosions and other boiler accidents, while in 1909 but six were killed and seven injured. In every case of fatal accident investigation showed the cause to be low water. The ratio of persons killed to locomotives in service in 1908 was 1 to 820, and in 1909, 1 to 1,248; the ratio injured in 1908 was 1 to 266, and in 1909, 1 to 524.

It is believed that the reduction in low water accidents has been due to a considerable extent to the improvement in the inspection of water glasses, gage cocks, and injectors.

The experience of the last two years has demonstrated the value of this part of the Commission's work, and has proved that the systematic checking of the railroad companies' inspectors and inspection systems will, if properly carried out, give satisfactory results. The appointment by the government of detailed boiler inspectors to duplicate or supersede the inspection work now carried on by the railroads would have the disadvantage of relieving the railroad companies of at least a portion of the responsibility which properly belongs to them, and in addition would be vastly more expensive than the present system.

Forest Protection.

Considerable attention is given in the report to the question of protecting forests in the Adirondack Forest Preserve from fires caused by steam locomotives. The Commission has ordered the installation of oil-burning locomotives by the New York Central & Hudson River R. R. Co. and the Delaware & Hudson Co. on their lines through the Adirondacks, effective April 15, 1910. All coal-burning engines operated during 1909 were inspected by representatives of the Commission and the ash-pans and spark-arresters of every coal-burning locomotive which was used in the Adirondack Forest Preserve last summer were carefully examined.

This involved the inspection of 109 locomotives at least once, and in many cases the inspection had to be made a second and occasionally a third time, as in the first inspection 67 of the locomotives, or 61%, were found to have defective spark-arresters or ash-pans, or both.

The New York Central has petitioned the Commission for a rehearing in this case, urging as a reason that the remedies applied by its operating officers during the past summer have been efficacious in preventing fires and that the additional expense of oil burning is not justified.

No rehearing in this matter has been requested by the Delaware and Hudson Co., and active preparations for oil burning by that company in accordance with the terms of the order are in progress.

Road Construction and Maintenance in Cumberland County, England.

By GEORGE JOSEPH BELL*, M. Am. Soc. C. E., M. Inst. C. E.

As macadamized road construction has been, from time to time, engaging the attention of the readers of Engineering News, I venture to give a brief account of the construction and maintenance of the main roads in the County of Cumberland, England.

The first care of a road engineer is to see that the subsoil foundation is quite dry. If not naturally so, then it should be made so by cutting a drain up the center of the road, from 3½ to 4 ft. deep, so as to be safe from the effects of frost, and placing in it 4-in. common field-drainage tiles, and filling up the drain with the excavated material. Suitable offlets should be made in connection with this drain at convenient distances, not too far apart.

The 4-in. tile drain is put in the centre of the road to cut off the capillary attraction, and so stop the moisture from getting above that point; thus securing a dry bed for the road itself. I do not want any surface water in that drain and it is best filled up with what is dug out. Many people think the drain is for the removal of surface water. This would not secure a dry bed for the road, which must be perfectly waterproof.

It should be remembered that the subsoil not only has to bear the traffic but the road surface itself, which should be made waterproof.

Now form the road bed, allowing a fall of 1 in. to the yard (1 in 36), from the center to each side. When this is done I follow Telford's plan, which is copied from the Roman system, and lay down a 6-in. layer of hand pitching, filling up the interstices with small

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gravel, when it can be conveniently got, or broken stone. I then pass the steam roller over this in a dry state to find out if there are any slack places. If so, they must be levelled up where shown. The foundation is then ready for a binding of good rich clay, which ought to be dug out and exposed for a few months before it is required. This must be well watered and rolled till it shows a fairly even surface. On this apply a 3-in. coat of 2-in. broken metal [stone]—I prefer it unscreened, just as it comes from the stone breaker. Give this coat a good binding of clay and apply water and roll it till the clay becomes a thin puddle, which must be swept about with brooms or brushes till the metal is quite covered up.

Apply a second 3-in. coat of metal and break all the large stones, if there are any, with a hammer before applying the clay binding. In applying this coat of metal, as in applying the first coat, every shovelful must be turned over and spread evenly with great care. Apply a coat of clay binding to this second coat of metal, puddle it well with water and sweep about the road while the roller is consolidating it. When it begins to dry spread some fine gritty screenings, about the size of peas, thinly over the whole surface and roll till the surface looks like fine concrete, and the road is finished.

I find that a 3-in. coat of metal is as much as can be properly consolidated throughout with a ten-ton steam roller. When so consolidated, and constructed as described above, a road will carry the heaviest traction-engine traffic hitherto met with on our roads without showing any signs of yielding. A road so constructed never heaves through the action of frost because the surface forms a roof on a dry subsoil, and keeps it waterproof. It is the yielding of a wet foundation that causes the road to break up and work into ruts.

In repairing a worn road which has become uneven on the surface, the road should be cut across with the pick, 6 ins. apart, and a stone deep. Strike the space loose between the cross cuts, adjust the loosened metal with the rake, apply a thin coating of new, finely-broken screened 1 or 1½-in. metal, bind with clay and treat as directed above. If the defective parts are in patches, then cut round each defective part with a pick, loosen the surface, level up the depression with new metal, bind with clay, water well and allow the traffic to run it in, if it is too small a job to employ a roller on.

The cost of maintenance for the upkeep of such a road runs from £40 to £50 [$200 to $250] per mile per annum, under the heaviest traffic, with motor cars of all kinds included.

A road constructed as described above yields few, if any, loose stones, and a minimum quantity of dust.

Wind, dry weather, and quick-moving motor cars are the greatest enemies to the surface of such roads, and to keep these tight and safe a little fine clay ought to be applied where the surface is seen to be breaking loose.

In making a new road from the bottom on the above lines, the cost runs about £1,200 [$6,000] per mile, including the making of the road and the fences on each side, but not including the purchase of the necessary land.

As long as motor cars are built as they are at present, so near to the ground, and allowed to travel at the present high speed, so long will the public be troubled with dust from any construction of road, no matter how such roads are treated.

In my opinion the firm of motor builders who will construct motor cars with larger wheels and practically solid tires, with the body of the car at least 21 ins. from the surface of the road, will command the trade of the future for this class of vehicle.

Notes from Engineering Schools.

UNIVERSITY OF ILLINOIS.—The Commonwealth Edison Company of Chicago and the General Electric Company of Schenectady have jointly presented to the Department of Electrical Engineering a 125-kw. steam turbo-generator. The turbine of this unit is to be run non-condensing. The generator is designed for three-phase, 60-cycle current at 2300 volts. This machine is the first large gift thus far ever received by the College of Engineering.

A PREMATURE EXPLOSION in the heading of the McKeel tunnel, now under construction on the new aqueduct for an additional water supply for the city of New York, killed 10 men and injured 5 others on the afternoon of Jan. 21. This tunnel is located south of the town of Cold Spring, Putnam Co., N. Y., on the east bank of the Hudson river. It is to be 980 ft. long and is of the standard section adopted by the Board of Water Supply for its water tunnels; that is, about 13 x 17 ft. The rock through which it is being driven is very hard, firm and dry so that no timbering is needed. At present about 533 ft. of the bore has been driven, entirely from the north end, and the 9-ft. heading is being worked about 28 ft. ahead of the bench.

The usual procedure of work included a heading round of 22 holes, 6 of which were for the center cut; these latter were from 8 to 9 ft. deep and the remainder from 7½ to 8 ft. The rock was so exceedingly tough and hard to break that it was necessary to fire the cut several times before blasting the side rounds. These successive blasts could be fired in fairly rapid succession, as it only took from 10 to 15 minutes for the smoke and gases to clear out sufficiently to allow the men to go back to reload. For the heading 60% dynamite was used and 40% for the bench; firing was done by battery from outside the tunnel.

There were only 15 men in the tunnel at the time of the explosion, and of this number, 10 were killed, including the foreman. The five who were saved were some distance back from the heading and managed to get to the portal without any outside assistance, but are so seriously affected by the concussion and the gas that they are not in condition to give a reasonable account of the events preceding the explosion. From interior conditions viewed subsequent to the accident, however, the engineers for the Board of Water Supply have made a report from which we have taken the following details:

At 2:30 p. m., Jan. 21, the first shot on the 6 center cut holes of the heading were fired, at 2:50 p. m., the second shot was fired and some 10 minutes later the men re-entered to load for the third shot. At 3 p. m. a much heavier explosion than usual attracted the attention of the men outside to the tunnel, and soon afterward the survivors were seen crawling from the entrance. Attempt was made to enter the tunnel to rescue the other men but the gases and smoke prevented any such rescue work for a full hour afterward. When finally the heading could be reached, eight of the bodies were found on the main bench just over the heading bench and two bodies, including that of the foreman, on the heading bench near the cut. None of the bodies was greatly mutilated as they would have been by a heavy fall of rock, but death had been caused by concussion, not by asphyxiation.

Examination of the ground showed no indications of an extensive explosion. The four upper holes of the six holes for the center cut were loaded preparatory to the third blast, but investigation failed to show that the lower two of these six holes had been loaded, although they were covered with the muck from the explosion.

Two explanations have been offered. The first is that the rock had become so heated from the two successive blasts as to have set off the powder as it was being loaded for the third blast. This is discredited. In the first place the dead foreman was known as a most careful man who certainly would have determined the heat of the holes before loading them. Then, the four upper holes of the cut still contain the load for the prospective third shot; had the explosion been in the heading these shots must certainly have been burned, thrown out or exploded. Finally, after each regular blast it was possible to clear the tunnel in 10 or 15 minutes, but the fatal explosion so fouled the air that it was an hour before entrance could be had. This would indicate that the explosion took place in the open bore and not from heating or by the accidental discharge of a previous misfire.

The other explanation is that the dynamite resting on the bench for use in loading the holes, probably a 50-lb. box, and perhaps more, was exploded by some shock, such as the falling of a small stone on a cartridge with exploder attached. This theory is borne out by the condition of the heading, which is not shattered as it would have been by an explosion in the holes, by the location and condition of the bodies and the evidence, noted above, that the explosion was in the open.

The tunnel was not seriously damaged and work has not been interrupted by the accident. The contractor on the tunnel is R. K. Everett & Co.

ANOTHER EXPLOSION ON THE WORK of the new aqueduct for the City of New York, occurred at the dynamite drying house at Shaft No. 5, near Forest Glen, Ulster Co., N. Y., on Jan. 22, and killed one man and injured three others. The cause of the explosion is not known.

AN EXPLOSION WRECKED A GAS PLANT at Benton Harbor, Mich., Jan. 20, and cut off the supply of illuminating gas from both that city and St. Joseph, Mich., which was supplied by the same plant. Four men were seriously injured. The plant was owned by the Benton Harbor & St. Joseph Gas Co.

A POWDER MILL EXPLOSION Jan. 17 destroyed one of the buildings of the Hamilton Powder Co. near Beloeil Station, Que. The employees were warned by an alarm system and none was killed although several received minor injuries.

AN EXPLOSION IN THE ELECTRIC PLANT at Paterson, N. J., Jan. 21, cut off the power from the lighting and trolley systems of that city for several hours. One man was fatally injured and two others were badly hurt but are expected to recover. The explosion took place in the boiler room and is ascribed to the bursting of a pipe in the economizer. The boiler room and boilers were considerably damaged but it was found possible to get four of the ten boilers into operation again within about 3½ hours after the accident. The plant has a total of 5,000 HP. in Stirling water-tube boilers and supplies practically all the electric light and power for the city of Paterson and its suburbs. It is owned by the Public Service Corporation of New Jersey.

A SERIOUS RAILWAY WRECK AT SPANISH RIVER, Ont., Jan. 21, on the Canadian Pacific Ry. caused the death of between 40 and 50 persons and the injury of about half as many others. The wrecked train was passenger train No. 7, running from Montreal, Que., to Minneapolis, Minn. As it approached the east end of the bridge across the Spanish River about four miles west of Nairn, Ont., at a speed of about 40 mi. per hr., the fourth car from the rear end of the train, a day coach, was in some way derailed. The derailed car plunged down the steep embankment into the river. A second-class coach immediately behind the derailed day coach went down the embankment but was prevented from reaching the river by striking the end of the bridge. It was crushed and caught fire. The last two cars of the train, a dining car and a sleeper, went down to the river bank and the dining car was partially submerged. The sleeper turned over on its side but did not enter the water. The locomotive and the first four cars remained on the rails.

Most of the persons killed were in the day coach, which was entirely submerged. Recovery of the bodies was made difficult by a blizzard on the day after the accident and by the freezing over of the river above the car. Reports of Jan. 26 give the number of known dead as 37.

A MOUNTAIN FREIGHT WAS DERAILED Jan. 20 on the Denver, Northwestern & Pacific Ry. near the summit of the Front Range, a few miles west of Antelope, Colo. The train got beyond control on the steep grade near Tolland, Colo., and its speed increased up to about 70 mi. per hr. before it left the track and plunged down the hillside. Three trainmen were killed and one other was injured.

A PASSENGER LOCOMOTIVE WAS DERAILED two miles west of Cincinnati, Ohio, Jan. 22, on the Cleveland, Cincinnati, Chicago & St. Louis Ry. Five trainmen were killed and 15 passengers were injured. The train was bound from Chicago to Cincinnati. The locomotive left the track while rounding a curve and was whirled around in such a way that it smashed into one of the coaches.

THE 20TH CENTURY LIMITED WAS DERAILED Jan. 25 at a crossover switch on the New York Central & Hudson River R. R., near St. Johnsville, N. Y. The engineer and fireman were killed. The train was bound from Chicago for New York City. A delayed train was on the track ahead of the limited and the crossover switch was set to pass the limited around the other train on an adjacent track. The signals cautioning the engineer to slow down for the switch were not noticed or were ignored for the limited took the crossover at full speed. The locomotive was derailed and turned over, but all the cars remained upright. The accident occurred at 5.40 a. m., and most of the passengers, none of whom was hurt, were in their berths.

TWO PASSENGER COACHES WERE DERAILED Jan. 19 on the Ohio & Kentucky Ry. nine miles from Jackson, Ky., and rolled down a 40-ft. embankment. Two persons were killed and five others injured. There were only 15 passengers in the two coaches.

EXTENSIVE FLOODS IN EUROPE AND AMERICA during the past two weeks resulted from the heavy snowfall of December and January and the subsequent thaws. The damage done in Europe is more unusual and probably rather more severe, than that in the United States. In this country many rivers have risen

to dangerous heights and have wrecked bridges, carried away buildings on low ground, and flooded the low-lying parts of towns and cities. Ice jams in the Ohio and Mississippi, and in some of the smaller streams of the Mississippi Valley threatened serious damage, but in most cases broke in time, being helped at some places by dynamiting. On the Kansas River, however, several wagon bridges were carried away by ice and flood scour. The worst piece of damage in the country, perhaps, affected the roadbed of the San Pedro, Los Angeles & Salt Lake Ry., where it runs through the Meadow Wash, in Nevada and Utah. The line is elevated very little above the bottom of the valley, and the rush of flood-waters destroyed large parts of the roadbed on the whole 100-mile length through the valley, so that traffic is broken off and reports have it, cannot be resumed for an indefinite length of time. Entire relocation and rebuilding of the line in this region is forecasted; the cost will hardly be less than five million dollars.

In Europe, high water stages are reported from Switzerland, where a long-continued thaw and rain falling on deep snow accumulations converted mountain streams into destructive torrents. Many avalanches and rock slides occurred with several deaths. In the north and east of France floods were quite general, and are reported higher than any experienced for 25 years. A railway wreck at Le Mans on Jan. 20 caused by a washout killed two persons. A despatch from Rheims of Jan. 19 reported the entire surrounding region covered with water. Paris was affected later, but also was more seriously damaged and on Jan. 26 the Seine is still rising. Several parts of the Metropolitan subway railway and of the north-south tunnel and subway were flooded and traffic interrupted, and street railway traffic was stopped in a few streets as early as Jan. 21. Two days later the Seine was about 20 ft. above normal stage, the highest since 1876, and by Jan. 25 was over 25 ft. above mean, so that many of the bridges in Paris were submerged nearly to the crown of the arch. On Jan. 25 the health authorities urged that drinking water be boiled, as the filter beds from which part of the city is supplied were infiltrated with floodwater. Some sewers had burst or been undermined, and it was reported that sewage was leaking into the subway. Several suburban localities are deeply flooded. The tributaries of the Seine had not yet gone down on Jan. 26, and rainy weather continued, so that more extensive damage may be expected.

THE NATIONAL WATERWAYS COMMISSION, of which Senator Burton of Ohio is Chairman, submitted a preliminary report to Congress on Jan. 24. The report is conservative in tone and favors careful and unbiased investigation by expert engineers before undertaking any project for waterway improvement. Space compels the postponement of a full abstract of the report to a following issue.

TRAFFIC ON THE CANALS OF NEW YORK STATE increased slightly in 1909 over the exceedingly lean year preceding, according to the report of Superintendent of Public Works Stevens, which has been summarized as follows:

All the canals carried during last season a total of 3,116,536 tons, as against 3,051,877 tons in 1908, and 3,407,914 tons in 1907. The season was shorter than in previous years by some months owing to the Barge Canal construction work, and the provision of the construction act, which provides that the open season shall not begin until May 15 and shall close on Nov. 15. The tonnage was made up as follows: 1,203,100 tons, way freight East; 330,520 tons, way freight West; 339,545 tons, through freight East, and 158,148 tons, through freight West.

The division of the tonnage by canals in comparison with the figures of 1908 is as follows: Erie Canal, 2,031,307 tons, as against 2,177,443 tons in 1908; Champlain Canal, 732,125 tons in 1909, as against 614,762 tons the previous year; Oswego Canal, 121,717 tons, as against 92,831 tons the previous year; Cayuga and Seneca Canal, 84,957 tons, as against 81,029 tons in 1908; Black River Canal, 146,430 tons, as compared with 85,812 tons the previous season.

The estimated total value of shipments for 1909 was: $59,081,572, as compared with $54,511,500 the previous season, and $63,903,970 in 1907.

The commodities of which there was an increased shipment last year were: Boards and scantlings, of which there were 404,080 tons, as compared with 358,954 tons in 1908; wood, 25,674 tons, as compared with 15,197 tons the previous season. Also, there were slight increases in other products of the forest. The wheat shipments were increased to 191,855 tons, as compared with 183,667 tons in 1908; oats increased to 79,564 tons, as against 61,011 tons the previous year; potatoes 7,394 tons, as against 4,041 tons in 1908. Pig iron was increased to 37,302 tons, as compared with 19,171 tons in 1908; domestic salt, 124,056 tons, as against 85,632 tons the previous season; bituminous coal, 170,673 tons, as against 140,209 tons the previous year. Among the items which show decreased shipments were: Lard, tallow, apples, flaxseed, sugar, stone, lime and clay and anthracite coal.

THE NEW YORK STATE BARGE CANAL is the main subject treated in the report for 1909 of State Engineer Frank M. Williams. That part treating of the progress on the work is as follows:

At the end of 1909 there were 314.2 miles of canal under contract at prices aggregating $54,138,829. Additional plans for 67.7 miles are completed, while the plans for 9 miles more are over 75% finished, and the plans for the remaining 20.5 miles are well under way. Thus 76% of the total length is under contract, and it is expected that the whole of it will be let by April 1, 1910, with the exception of some minor structures.

Fifteen of the 53 new locks are now completed. By a year from next spring the eight movable dams in the Mohawk River will be in operation. The large fixed dam across the Mohawk near Crescent will be finished during the next summer, as will also the concrete dam impounding the waters of the upper Mohawk at Delta in a reservoir having a flooded area of 2,800 acres.

At the close of 1909 the total value of all construction work equals $16,291,325. As the record to the end of 1908 was $8,701,323, it appears that nearly half of all the work done thus far has been performed during the past year, although several contracts were let so late in the year that they have contributed but little to the record. When compared by years, the excellence of this year's record is manifest. At the end of 1905, $330,120 had been expended; by the close of 1906 the total was $1,042,926, while the sum had reached $3,257,461 and $8,701,323 at the ends of 1907 and 1908, respectively. Of the 314 miles of canal under contract 120 miles, or 38%, have been awarded during 1909. The total price of contracts let during the year amounts to nearly $19,000,000, or more than one-third of the whole under contract. With three-quarters of the work under contract, it seems assured that all the construction contemplated by the Barge Canal act will be entirely completed within the original appropriation.

A LONG-DISTANCE ELECTRICAL TACHOMETER has been devised by Mr. M. R. Hutchison, of New York City, which is particularly suited for marine use to indicate to the man on the bridge or in the pilot-house the speed of the propeller shaft. The indicating instruments are, essentially, alternating-current voltmeters connected to the terminals of magnetos driven by the propeller shaft. The voltmeter scales are calibrated in revolutions per minute and the direction of rotation is shown as well as the speed.

The magnetos are mounted on a bracket in the shaft alley and are driven from the shaft by a Renold silent chain. A split driving sprocket is bolted to the propeller shaft and the driven sprocket is coupled through a flat-coiled spring to a flywheel five or six inches in diameter. The spring coupling was found necessary to prevent vibration of the indicating needle of the voltmeter due to angular variations during each revolution of the propeller shaft. A safety stop is provided to prevent excessive strain on the spring when the propeller speed is changed suddenly.

The face of the magneto flywheel is several inches wide and carries, at the edge further from the chain sprocket, an internal gear which meshes with the magneto pinions. Two magnetos are used, set side by side and both driven by the internal gear in the flywheel. The magneto shafts are so arranged with respect to the gear that they work together exactly in phase—that is, when the propeller revolves in the "ahead" direction. When the propeller is reversed, the direction of rotation of the flywheel with its internal gear also changes, of course, and reverses at the same time the magneto pinions. But one of the pinions is arranged to slip 90° on its shaft when its direction is reversed and in this way the magnetos are put 180° electrically out of phase with each other when the propeller rotates "astern." The magnetos used on a working model of the tachometer at the New York office of the Industrial Instrument Co. were of the Bosch low-tension inductor-alternator type with a stationary armature with continuous primary and secondary winding mounted between the pole shoes of three powerful steel horseshoe magnets, and a soft iron sleeve, consisting of a tube having two slots each representing a quarter of the circumferential area of the tube, that rotated between the stationary armature and the pole shoes. One of the magnetos is connected electrically to the moving coil of the indicating instrument, the other to the fixed coil. When the two magnetos operate "in phase" the needle of the voltmeter, or indicator, is deflected in one direction; and in the other direction when they are 180° "out of phase."

In the normal position, the indicator needle stands at zero at the mid-point of its scale. The deflection of the needle is proportional to the magneto voltage, which in turn is proportional to the speed of the propeller shaft. In multiple-screw ships, an indicator is provided for each propeller shaft and, if desired, several sets of indicators may be installed on each magneto circuit at various points about the ship. A special binnacle indicator with a non-magnetic brass case is provided for use alongside the compass binnacle.

The Hutchison tachometer is manufactured by the Industrial Instrument Co., Foxboro, Mass., and its essential features have been patented. One of these tachometers has been in use a year and a half on the U. S. cruiser "Tacoma" and at the end of this time showed variations in accuracy of calibration of less than 1%. This permanence of calibration is ascribed to the fact that there are no moving contacts in the entire circuit.

THE GREATEST GOLD MINE of the world is now in America, the Goldfield Consolidated, of Goldfield, Nevada, having surpassed in output the famous Robinson mine in the Transvaal. The latter, which for some years had exceeded all others, reached an annual production valued at $4,500,000. The Goldfield Consolidated Mines Co., now reports a production of $6,832,652, for the last fiscal year. There were 194,479 tons of ore milled. The net profits were $5,026,619, of which $5,000,000 was distributed in dividends. The cost of treatment has been reduced to $6.77 per ton, including fixed charges. The extraction reached 94.49%, and the average assay value of ore sent to the mill was $33.45 per ton. These results have been possible by a remarkable milling plant built in accord with latest practice and free from all disadvantages of reconstruction. Some 800,000 tons of ore reserves have been developed—a four years' supply, which is considered a safe working margin. Additional equipment is being installed so that the production for the current year will be greater than that reported above.

A LARGE ASPHALTUM DEPOSIT in Cuba is being developed by the Havana Exploration Co., Ltd., of London and Havana. The deposit is located near the port of Mariel, some 30 miles from Havana. The deposit covers an area of over 2,200 acres, lying at a depth of 5 ft. to 20 ft. below the surface. It is said that borings have shown a thickness of over 300 ft. Asphaltum has been taken from this deposit at the rate of 10,000 to 15,000 tons a year for some time, and has been marketed in St. Louis and Chicago. The company above named, which secured control of the property a year ago, has installed a new plant and machinery and is stripping the surface soil with a long-boom excavator furnished by The Browning Engineering Co., of Cleveland. With this plant installed, it is claimed that an output of 200,000 tons of asphaltum can be reached during the present year. The asphaltum is said to give excellent results in paving compositions and to withstand extremes of temperature particularly well. The company has built a railway line from the mines to the harbor, and will erect wharves and loading facilities. The above information is taken from a recent issue of the Havana "Post."

ELECTRIC RAILWAY CONSTRUCTION in 1909 consisted of 887.16 track miles against 1,258.51 miles built in 1908. The figure for 1908 was less than that for 1907 but the falling off was greater in 1909 than in 1908, due to the after effects of the depression of 1908. Projects under way at the beginning of 1908 were completed but few new ones were started in that year. Few projects started in 1909 were finished in that year. Much new work was actually started in 1909 and this should result in a large increase for 1910. New York State built the most track—129.08 miles. These figures were given in detail in the "Electric Railway Journal" Jan. 1.

Personals.

Mr. O. C. Gayley, of New York City, has become Vice-President of the Western Steel Car & Foundry Co., succeeding James W. Friend, who died Dec. 26.

Mr. John W. Hill, M. Am. Soc. C. E., the consulting sanitary engineer of Cincinnati, Ohio, has been appointed a member of the Ohio State Board of Health to succeed Dr. Byron Stanton, of the same city.

Mr. B. F. Cresson, Jr., M. Am. Soc. C. E., formerly Resident Engineer of the Pennsylvania R. R. tunnels under the Hudson River at New York City, has been appointed Deputy Commissioner of Docks and Ferries of New York City. Mr. Wm. J. Barney has been appointed Secretary to Mr. Calvin Tomkins, the Commissioner of Docks and Ferries.

Mr. Merrill Watson, Assoc. Am. Soc. C. E., General Sales Manager of the Consolidated Expanded Metal Cos., of which he has been the representative in New York City for the past 14 years, has become European representative for a number of lines of concrete reinforcement. Mr. Watson sailed Jan. 22 for London, and will be absent for several months.

Dr. Edward G. Acheson, M. Am. Inst. E. E., President of the International Acheson Graphite Co., Niagara Falls, N. Y., has been presented with the Perkins medal for his attainments in applied chemistry. The presentation was made by Professor C. F. Chandler, of Columbia University, at a recent meeting of the Society of Chemical Industry, held in New York City.

Mr. Lewis D. Thorpe, of Boston, Mass., will continue the business formerly conducted by him in partnership with Freeman C. Coffin, who died Nov. 11, 1906. Mr. Thorpe's offices are now in the Boston Safe Deposit & Trust Co. Bldg., 201 Devonshire St., Boston, Mass. He will give especial attention to water-supply, purification of water and sewage treatment.

Mr. Carl R. Weidner, Jun. Am. Soc. C. E., has been appointed instructor in hydraulic engineering at the University of Wisconsin. Mr. Weidner was formerly employed by the Prairie Oil & Gas Co., but resigned that position in 1907 to spend six months in Europe. Upon his return to the United States, he became instructor in hydraulic engineering at the Pennsylvania State College and held this position up to the time of his present appointment.

Mr. Ira W. McConnell, whose resignation as Supervising Engineer, U. S. Reclamation Service, was noted in our issue of Oct. 14, 1909, has joined the staff of J. G. White & Co. incorporated, with the title of Chief Irrigation Engineer. At the time of Mr. McConnell's resignation from the Reclamation Service last Fall, soon after the completion of the Gunnison tunnel, which was constructed under his supervision, it was announced that he would enter private practice. An outline of his past work and experience was published in this column on the date already given.

Mr. F. A. Hall, M. Am. Soc. M. E., Manager of the chain block and hoist department of the Yale & Towne Mfg. Co., 9 Murray St., New York City, for the past twelve years, has resigned that position to become Vice-President and Treasurer of the Cameron Engineering Co., of Brooklyn, N. Y. Mr. R. T. Hodgkins, who has been Mr. Hall's chief assistant for several years, will succeed him as Manager of the hoist department of the Yale & Towne Mfg. Co. In his new position, Mr. Hall expects to make a specialty of trolleys and appliances for overhead handling of materials.

Mr. D. S. Watkins, Division Engineer of the Buffalo, Rochester & Pittsburgh Ry., at Du Bois, Pa., has been appointed Engineer of Construction with headquarters at Du Bois. Mr. G. C. Cleaver, recently Assistant Engineer of Track, at Rochester, N. Y., has been appointed to succeed Mr. Watkins as Division Engineer at Du Bois, Pa. Mr. W. F. Pond, formerly Assistant Engineer of Bridges, has been appointed Office Engineer at Rochester, N. Y. Mr. F. W. Hamomnd has been appointed Division Engineer at Rochester, N. Y. The positions of assistant engineer of track and assistant engineer of bridges have been abolished.

Mr. Alexander Johnson, Assoc. M. Am. Soc. C. E., has been appointed Chief Engineer of the Department of Bridges of New York City, with a salary of $10,000 a year, to succeed Mr. Kingsley L. Martin, M. Am. Soc. C. E., recently advanced to the office of Bridge Commissioner. Mr. Johnson was born in Brooklyn, N. Y., in 1869, and is a graduate of the Sheffield Scientific School, Yale University. He has been closely identified with the construction of New York City's East River bridges since 1896. During the construction of the Williamsburg Bridge, he was Assistant Engineer under Mr. L. L. Buck. Early in 1908 Mr. Johnson was appointed Consulting Engineer in the Department of Bridges, and in this capacity he had charge of the erection of the Manhattan Bridge. He was recently engaged as Consulting Engineer in connection with the design and construction of the new Municipal Building.

Mr. Charles Kirchhoff, who recently resigned from the chief editorship of "The Iron Age" after more than 30 years of service, was the recipient of a complimentary luncheon given at the Engineers' Club, New York City, on Jan. 16 by a large party of engineers and personal friends. The luncheon was arranged for by a committee made up of Messrs. Philip T. Dodge, President of the Engineers' Club; T. Commerford Martin, E. C. Brown, Joseph Struthers and Theodore Dwight. Besides those present at the luncheon, tributes were received from many unable to be present, including among others Dr. James Douglas, Henry M. Howe, John Hays Hammond, Andrew Carnegie, Robert W. Hunt, Theodore N. Ely, Col. H. G. Prout, and Hon. William H. Wiley. The luncheon was made the occasion for the presentation to Mr. Kirchhoff, on behalf of his associates in the David Williams Co. (publishers of "The Iron Age"), of a fine bronze statue by Picault.

In the informal addresses following the luncheon, many engineers joined in paying tribute to Mr. Kirchhoff's high character and great service to the profession in his many years of editorial work. Among the most notable of the addresses were the remarks by the venerable John Fritz, who, despite his 87 years, came from South Bethlehem to attend the luncheon. Among the other speakers were Dr. R W. Raymond, Secretary of the American Institute of Mining Engineers, of which Mr. Kirchhoff is a Past-President, and President Henry S. Drinker, of Lehigh University.

Mr. Kirchhoff has relinquished his active work as editor of "The Iron Age," and will take a well-earned rest. He is spending the winter months in a cruise through the West Indies. Later he expects to devote himself to some work of a public character.

Obituary.

Charles H. Bennett, Chairman of the Board of Water Commissioners of Springfield, Mass., died Jan. 19. Mr. Bennett had been a member of the Springfield water board since 1902.

Lercy M. Harvey, Sales Manager of the Milwaukee district office of the Allis-Chalmers Co., died at Augusta, Ga., Jan. 19. He was born in Oak Park, Ill., and was about 37 years of age.

William Eardley, an iron work contractor of Paterson, N. J., died Jan. 17 in Oakland, Cal., from injuries received while attempting to board a train at that city. Mr. Eardley went to Oakland about three months ago to take charge of work in that vicinity for which he held the contract.

Robert Irving Stevens, an instructor in the forge and foundry shops of Stevens Institute, died Jan. 19 at his home in Bloomfield, N. J., aged 35 years. Mr. Stevens had been associated with the Stevens Institute shops about 15 years.

Walter A. Brown, formerly Assistant City Engineer of Springfield, Mass., died Jan. 18, at the home of his father in that city. Walter Brown was born at Lowell, Mass., in 1869 and was a graduate of the Massachusetts Agricultural College in the class of 1891. He entered the city engineer's office at Springfield as an assistant soon after his graduation and remained in that employ until 1907, when he removed to Greenfield, Mass., to engage in private business.

Samuel R. Probasco, M. Am. Soc. C. E., formerly Chief Engineer of the department of bridges of New York City, died Jan. 19 at his home in Burlington, N. J., from infirmities due to old age. Mr. Probasco was born on Manhattan Island and educated in the public schools of New York City. After returning from California, where he had gone at the time of the excitement following the discovery of gold in 1849, he took up the study of civil engineering. He was first employed in connection with work on the Brooklyn Bridge in 1875 and remained continuously in the employ of the New York bridge department for many years. He was Chief Engineer of the department from 1898 to 1901. Mr. Probasco was a member of the Brooklyn Engineer's Club and the Municipal Engineers of the City of New York.

Fayette Brown, President of the Brown Hoisting Machinery Co., died Jan. 20 at his home in Cleveland, Ohio. Mr. Brown was born at Bloomfield, Trumbull Co., Ohio, in 1823. He was at first associated with his brother in the dry goods business and, after moving to Cleveland, in 1851, he operated a banking firm until the outbreak of the Civil War. He served as a paymaster in the U. S. Army during the war for about a year and upon returning to Cleveland he became General Agent and Manager of the Jackson Iron Co. with which he was connected until 1887. In 1880, Mr. Brown, with his two sons, Harvey H. and Alexander E., organized the Brown Hoisting & Conveying Co. which has since been reorganized into the Brown Hoisting Machinery Co. At the time of his death, Mr. Brown was chairman of the Stewart Iron Co. and President of the Union Steel Screw Co. and the National Chemical Co.

Edward Payson Bryan, formerly President of the Interborough Rapid Transit Co., of New York City, died Jan. 23 at San Juan, Porto Rico. Mr. Bryan was born at Windsor, Ohio, in 1847 and was educated in the public schools at Granville, Ohio, and in the preparatory department of Dennison University. At the age of 18 years, he secured a position as telegraph operator with the Louisville & Nashville R. R. at Lebanon, Ky. He continued in the sevice of this same railroad until November, 1905. During the last four years of his service with the Louisville & Nashville R. R., he was Superintendent of Terminals, one year at Louisville, Ky., and three at St. Louis, Mo. In November, 1905, he was made Vice-President and General Manager of the Terminal Railroad Association of St. Louis, and the St. Louis Union Terminal was built under his supervision during his five years in this position. Mr. Bryan came to New York City in the Spring of 1900 and on May 1 of that year became Vice-President of the Interborough Rapid Transit Co. and the Rapid Transit Subway Construction Co. He was advanced to the presidency of the Interborough in 1905 and resigned from that position in the latter part of 1908. His next work was in San Francisco, Cal., as General Manager and Vice-President of the Great Western Power Co., which position he held until July, 1909. At the time of his death, he was spending the winter in Porto Rico with one of his five sons.

Engineering Societies.

COMING MEETINGS.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 8. Annual meeting at New Haven, Conn. Secy., J. Frederick Jackson, Box 1304, New Haven, Conn.

OHIO ENGINEERING SOCIETY.
Feb. 8-10. Annual meeting at Columbus, Ohio. Secy., C. J. Knisely, New Philadelphia, Ohio.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 16. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, E. Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 16-17. Annual convention at Cedar Rapids, Iowa. Secy., A. H. Ford, Iowa City, Iowa.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Feb. 18-21. Annual convention at Chicago, Ill. Chairman, notification committee, O. U. Miracle, Minneapolis, Minn.

NATIONAL ASSOCIATION OF CEMENT USERS.
Feb. 21-26. Annual convention at Chicago, Ill. Pres., Richard L. Humphrey, Harrison Bldg., Philadelphia, Pa.

ENGINEERING SOCIETY OF WISCONSIN.
Feb. 23-25. Annual meeting at Milwaukee, Wis. Secy., W. G. Kirchoffer, 31 Vroman Bldg., Madison, Wis.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Feb. 24-26. Annual meeting at Chicago, Ill. Secy., D. J. Hauer, 721 Park Row Bldg., New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
March 1-5. Annual meeting at Pittsburg, Pa. Secy., R. W. Raymond, 29 West 39th St., New York City.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 15-17. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 962 Monadnock Block, Chicago, Ill.

IRON AND STEEL INSTITUTE.—The annual general meeting will be held May 4-5 at the Institution of Civil Engineers, Great George St., London. The autumn meeting will be held at Buxton, England, Sept. 27-29.

ILLUMINATING ENGINEERING SOCIETY.—Officers for the coming year have been elected as follows: President, Edward P. Hyde; Vice-President, V. R. Lansingh; Treasurer, W. C. Morris; General Secretary, P. S. Millar, 25 West 39th St., New York City; Directors, L. B. Marks, E. B. Rosa and E. W. Lloyd.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The meeting at Charlotte, N. C., has been postponed one week and will be held March 30-April 1 instead of March 23-25, as formerly announced. An advance list of the papers to be presented at this meeting was published in our last week's issue.

CHEMISTS' CLUB.—A ten-story club-house and office building is to be erected at 50-54 East 41st St., New York City. The main floor will contain a large auditorium, the second floor will be fitted as a luncheon room and on the third floor will be the library and museum. The fourth and fifth floors will be devoted to sleeping and living rooms for members.

COUNTY ENGINEERS OF NEW JERSEY.—At the annual meeting in Trenton, N. J., Jan 17, officers were elected as follows: President, Frank J. Eppele, Mercer Co.; Vice-President, W. E. King, Morris Co.; Secretary, E. E. Read, Trenton; Treasurer, Joshua Doughty, Somerset Co. The meeting indorsed the recommendation to ask the State Legislature for a regular annual road appropriation of $300,000. The effect of the increasing automobile traffic on the roads and road building was mentioned as the reason for this action.

INTERNATIONAL STREET AND INTERURBAN RAILWAY ASSOCIATION.—Program for the 1910 meeting of the International Street and Interurban Railway Association, Brussels, Belgium, Sept. 7-10, has been announced. The following topics will be considered by committee reports. (1) Legislation for European Local Railways, (2) Proper System of City Extension for Best Transportation Facilities, (3) Internal-Combustion Engines, (4) Construction and Maintenance of Overhead Lines, (5) Improvements in Rolling Stock, (6) Watt-meters and Current Recorders for Cars, (7) City-Track Construction, (8) Rail Corrugation, (9) Ties, (10) Classification of Accounts.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—Action on the death of Dr. Charles B. Dudley, President of the association, which occurred Dec. 21, 1909, was taken at a meeting of the executive committee held Jan. 17. The preliminary announcement of this action, details of which are to be given out later, mentions a memorial session to be held at the next annual meeting and the proposed publication of a memorial volume commemorative of Dr. Dudley's life and work. A committee, specially appointed for the purpose by Mr. R. W. Lesley, Vice-President of the American Society for Testing Materials, nominated Dr. Henry M. Howe for the vacancy on the council of the international association occasioned by the death of Dr. Dudley. Members of the council are elected by the members in the country represented. Letter ballots for the election of Dr. Howe have been sent out to the American members. The First Vice-President, Professor A. Martens, will act as provisional head of the association until the nomination of a member of the council to be acting president.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—The second annual meeting will be held at Chicago, Ill., May 23-26. Among the papers prepared for this meeting by the committees named are the following: "Grade of Fuel Most Suitable for Locomotive Use, Considering Cost per Unit of Traffic and Best Interests of the Producer" and "Recommended Methods of Preparing Coal as to Size for Locomotives," J. G. Crawford, Chicago; Le Grand Parish, Cleveland, Ohio, and Curtis Scovill, Dallas, Tex.; "Standard Uniform Blank for Reporting All Items of Cost in Connection with Fueling Stations and Fuel Handling," R. Emerson, South Bethlehem, Pa.; F. V. Hetzel, Nicetown, Pa.; A. E. Averill, New York City, and N. M. Rice, Topeka, Kan.; "Accounting for Fuel Consumed: Individual Records of Performance," W. E. Symons, Chicago; E. A. Foos, Chicago, and E. J. Roth, Jr., Baltimore, Md.; "Methods of Purchasing Fuel," W. H. Huff, Denver, Colo.; L. L. Chipman, Kansas City, Mo., and W. K. Kilgore, Chicago; "Methods of Supervision, Instruction and Encouragement in Locomotive Operation to Secure Greatest Efficiency in Fuel Consumption," D. Meadows, St. Thomas, Ont.; W. C. Hayes, New York City; J. McManamy, Grand Rapids, Mich.